Growing Little Learners: enabling trainee teachers to support children's learning in primary science using the outdoors.

Alison Murphy

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Dedication:

For Joseph and Hannah

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Abstract

This thesis explores the ways that outdoor learning is specifically conducive to the support and facilitation of primary science education. Whilst developing practice-led principles for trainee teachers and teachers new to outdoor learning pedagogies, it also challenges the perception of the use of the outdoors being less academic or "risky fun" (Glackin 2016, p.1). The thesis looks at science as being made accessible and meaningful through "getting more from getting out" (Scott and Boyd 2016, p.1). Additionally, by contrast to much of the literature on outdoor science that focuses on professional perceptions and confidence (Waite 2011; Glackin 2016; Harris 2017), this research reports on learning outcomes and the impact on children's attainment.

Across three case study schools, the frameworks from Bloom *et al.* (1956) and Jelly (1985) were used to support the design and analysis of an outdoor primary science learning matrix. The trainee teachers based in each of the three schools used the matrix to chart and reflect on the ways that children were 'thinking scientifically' through assessing the science learning in the outdoors.

The researcher's analysis of the data generated from interviews with the trainee teachers revealed that when learning science is based in the outdoors, young children are well-placed to demonstrate higher order thinking skills beyond those expected of them within end of Key Stage outcomes (GB.DfE 2013). Specifically, children were seen to develop a set of scientific dispositions involving thinking scientifically, behaving scientifically and questioning scientifically. As such, the trainee teachers used the matrix to foster scientific attitudes such as curiosity, seeking out evidence to support their thought processes and metacognitive aptitudes including reflection and taking ownership of their learning progression.

The researcher's analysis provides exemplification to support trainee teachers, teachers and leaders to understand progression and pitch outdoor learning expectations in ways that enable the setting of challenging individual targets in outdoor science (Ofsted 2011) in line with the end of Key Stage outcomes (GB.DfE 2013).

List of acronyms

ASE	Association for Science Education
GCSE	General Certificate of Secondary Education
IBL	Inquiry-Based Learning
PSTT	Primary Science Teaching Trust
QCDA	Quality and Curriculum Development Agency
STEM	Science Technology Engineering and Maths
UNESCO	United Nations Educational, Scientific and Cultural Organisation

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Introduction

1.1 The aim of the research

This thesis originates from discussions that I have had with science specialist teachers in primary schools during national conference proceedings with the Association for Science Education (ASE) and Primary Science Teaching Trust (PSTT). During these discussions, the teachers I spoke to generally recognised the value of outdoor learning, but needed evidence to justify incorporating outdoor learning into their science teaching. Teachers tended to report that they required validation to change teaching methods that had been ratified by the headteachers and schools' governing bodies. Thus, the impetus for this research is to provide evidence to validate outdoor science within the science primary curriculum in order to support pedagogical changes.

Although science as a whole is classed as a core subject (Ofsted 2013) and is compulsory to the age of 16, it is frequently given the same priority in schools as a foundation subject such as history, geography or art. These subjects are lower in priority resulting in them being taught in less depth, with fewer teaching hours being allocated to science per week (Ofsted 2002; Caldwell *et al.* 2020). The current political climate focuses on standards in which the government prioritises English and maths (GB.DfE 2019d; Ofsted 2019d). It is essential that science is given renewed status and elevated to the same position as English and maths within primary education, in order to equip children with 'Science Capital'. This includes the STEM (Science Technology Engineering and Maths) subject skills required to be scientists and engineers of the future (Sokolowska *et al.* 2014; Archer *et al.* 2015).

The need to prioritise science within education is also highlighted by the science skill shortage in the UK. STEM jobs have surpassed non-STEM jobs since 2003 and science is seen as vital to the British economy with science skills needed to meet employment demands (EMSI 2019). In 2017 40% of employers reported a shortage of STEM graduates and 7 in 10 businesses found it difficult to hire staff with the required science skills (GB.HM Government 2017). STEM is the second biggest employer behind digital technologies, of which 60% of the jobs in the digital industry require STEM skills, and there is an increase of 3.1% in STEM careers forecast to 2026, compared with 2.5% in non-STEM roles (EMSI 2019). If these jobs are to be filled, then science in schools needs to prepare those children who are passionate about science for further study and science careers but also equip *all* children with scientific literacy or science citizenship (GB.SCST 2000) for future employment.

To enable children to develop a passion for science, an interest needs to be triggered, then extended and deepened through pathways into science. This has been found to occur through out-of-school activities, enquiry-based learning and making connections in the learning (Crowley *et al.* 2015). Engaging with science through nature in outdoor settings along with 'tinkering' and 'experimenting', were found to promote lifelong-science learning (Crowley *et al.* 2015). Outdoor learning allows children to experience science in action, regularly and at first hand (Ofsted 2013). Outdoor learning is particularly well placed to lend itself to learning science in several ways including providing opportunities to develop a love of the natural world, opportunities for visual observation and sensory experiences along with other basic skills, encouraging children to adopt ethical approaches when dealing with living things as part of science literacy and fostering imagination and creativity (Cutting and Kelly 2015).

There is a need to recognise and validate the evidence of learning in order to inform quality judgements and next steps for the children (Ofsted, 2011). An example of this is Forest School, which involves child-centred learning in outdoor educational settings. It focuses on holistic development through regular opportunities for play, exploration and risk taking; where personal, social and emotional development are reported upon in many counts (Knight 2011; O'Brien 2009). However, understanding children's engagement was rarely interrogated (Waite 2007; Cutting and Kelly 2015) and the links with their academic progress were rarely explicit (Glackin 2016; McCree, Cutting and Sherwin 2018). Prior to this research, the assessment of learning outdoors was not reported on by schools. In order to provide teachers with the skills to assess and report on the learning, it is necessary to 'allow' teachers the autonomy to create authentic opportunities by adjusting their practice and encourage them to see the potential of *out of classroom teaching*. While this thesis is primarily about the specific advantages of outdoor learning for primary science in ways that aim to provide practitioners with evidence-based pedagogical research to enable change to practice, it also acknowledges the restrictions on teachers' professional autonomy.

1.2 My personal rationale

I am a teacher educator working primarily with trainee teachers studying the primary education undergraduate degree. I lead the fourth year Bachelor of Arts (BA) degree and the trainees leave with Qualified Teacher Status (QTS) and 160 days placement experience. I consider myself to be a reflective practitioner and a researching professional by reflecting-on-action (Schon 1983). This has been possible by connecting both theory and practice and as a result of learning from experience, gaining new insights, examining assumptions, being self-aware and critically evaluating processes (Finlay 2008). In an era of diminishing teacher autonomy (OECD 2016; Worth and Van den Brande 2020), many teachers find they are unable to enact change in their practice. However, my own role anticipates innovation and research-informed practice much more readily. I am well placed to reflect upon the uncertainty associated with outdoor learning in order to better understand the progression of children's scientific learning (GB.DfE 2013). By extension, trainee teachers can be encouraged to think and work reflectively-in-action (Schon 1983), learning through and from experience, enabling them to consider their thoughts and choices with a view to improving the effectiveness of their practice (Finlay 2008). Science specialist trainee teacher are involved with this research, in the role of facilitators, and bring with them established relationships with the children and an insight into the learning. They also offer fresh ideas, together with an inquisitiveness and thirst for knowledge. They are happy to try out new approaches and take ethically considered risks. The Core Content Framework (GB.DfE 2019a), which defines the minimum entitlement for trainee teachers, encourages trainees to make connections (standard 4.2) and reflect on their practice (standard 8.2), providing a gateway for trainees to take advantage of outdoor learning for primary education purposes. Therefore, working alongside trainee teachers in the area of outdoor primary science education offers the scope to develop practices that may be novel.

Within my personal reflections, I recall the feeling of freedom of the outdoors from an early age, being immersed in nature, valuing its beauty but also being wary of its potential dangers. Appreciating the balance between the moments of awe and wonder and those of fear or uncertainty. In line with Steiner (1894) who valued opportunities for free thinking and purpose in nature, I see nature as a learning tool that can help children to exceed learning expectations. My passion comes from my own inquisitive nature and, when working with children, seeing nature as a window into how things work, whether that be through genetics and lifecycles or base principles such as energy, inertia or aero dynamics. This led to conversations with teachers and trainees about their current experiences of teaching science in the outdoors and highlighted a variety of constraints which limited their autonomy and ability to incorporate the outdoors into their practice. They were missing the opportunity to put science into action and encourage active engagement based on real-world experiences.

I understand *Outdoor learning* to be a process that consists of an active engagement with the outdoors in order to make sense of the world. Outdoor learning is understood by Dierking *et al.* (2003) as first-hand experiences of nature where the learning is embedded in the outdoor context and is derived from real-world experiences. Similarly, Rickinson *et al.* (2004) suggests that it offers unique opportunities for children to develop and deepen skills as well as knowledge, understanding, awareness, values, ideas, feelings and the capacity to reflect. Within this study, I have defined *outdoor science learning* as 'authentic opportunities to learn science outside of the school building', which enable active learning and provide substantial interaction with the environment.

Outdoor science learning fosters an assortment of essential science skills, knowledge and attitudes, which cannot be accessed indoors (Rickinson *et al.* 2004; Glackin 2016; Ayotte-Beaudet *et al.* 2017). This involves children being immersed in these surroundings and having the freedom to take ownership of their own learning through their engagement with nature. It is seen to focus on providing first-hand sensory opportunities for real-world problem solving, for example witnessing life processes (Linnean Learning 2019) and promoting biodiversity (Eco-Schools Northern Ireland 2019). The value of these opportunities cannot be underestimated in enabling children to become curious, creative, reflective and self-confident (Waite 2011).

Whilst these definitions align with the focus of this thesis, there are contentions associated with how outdoor science learning is perceived and applied. For example, teachers place greater emphasis on social and behavioural aspects as opposed to the scientific cognitive and affective elements (Becker *et al.* 2017), they treat the experience as a novelty and they also feel limited by potential barriers such as time and child to adult ratios (Glackin 2016). This thesis challenges the perception of the use of the outdoors being less academic and explores authentic science. It shows that using the outdoors has the potential to extend children’s cognitive learning through the application of scientific skills and approaches. This thesis uses authentic situations and real problem solving to make the abstract more concrete. This aligns with Scott and Boyd’s (2016, p.1) view of: “Getting More from Getting Out”, which found a significant increase in the children’s literacy and learning of ecology as a result of a fieldwork based intervention.

1.3 How can ‘science learning’ be defined in primary schools?

Before exploring science learning, it is perhaps useful to first define learning. Learning is generally understood as far more complex than acquiring new information and demonstrating recall (Roediger and Butler 2011; Karpicke *et al.* 2014). In line with the constructivist approach taken within this thesis, learning has been defined as a process of change that occurs as a result of experience (Argyris and Schon 1996). It includes: cognitive change in thinking and knowledge (Krathwohl *et al.* 1964; Shayer and Adey 2002); conative acquisition of skills and habits; and affective change in emotions (Kolbe 1990; Snow, Corno and Jackson 1996). It also involves the synthesis of old and new experiences to create new patterns within thinking which have the potential to improve future learning and be long lasting. Within this thesis, significant learning moments have been identified as:

- when a child first does something unaided or when they are able to do something with help which they were unable to do without (Vygotsky 1978);
- when they take risks, recognise errors and acknowledge misconceptions (Walters and Begley 2007; Little 2020);
- when they are immersed in the learning (Csikszentmihalyi, Abuhamdeh and Nakamura 2014; Coburn and Wallace 2017);
- or when there is a shift in their constructed understanding of the world (Piaget 1978).

Critical incidents are occurrences that typify or illuminate a particular feature of learning and reveal something unusual or non-routine within the learning (Flanagan 1949), such as an event which initiates a turning point or change (Tripp 2012). They are also significant because they provide insights about the children’s conceptual understanding as part of the process of learning.

There is no single agreed definition of what science learning encompasses (Sharp *et al.* 2017) and some authors debate the ambiguity about the nature of science (Holbrook and Rannikmae 2009). The lack of alignment and inconsistency in the defined characteristics can lead to some teachers developing misconceptions about enquiry and misunderstandings about the role of both teacher and child in enquiry-based instruction (Reif 2008). This is exacerbated by Ofsted (2021) which questions the value of child-led enquiry and notes caution in relation to guided enquiry; with value being placed on controlled scaffolded enquiry, direct instruction and explicit pre-teaching.

Primary school science was defined by UNESCO (1982, p.27) as: "the development of an enquiring mind; promoting children's intellectual development, including thinking in a logical way and problem solving; improving the quality of children's lives; assisting in other subject areas, especially language and mathematics; equipping children for living in an increasingly scientific and technological world". This definition is internationally understood and focuses on the wider, overarching benefits of science learning, whilst putting the child at the centre of the learning (Harlen and Elstgeest 1993; Wadhwa *et al.* 2018). This understanding of science learning in particular holds resonance with Dewey (1910) who focused on equilibrium, connection and engagement through experimentation within his five steps of effective learning. He believed that emotional and intellectual responses enable children to solve problems through active participation. He saw children as being characterised by curiosity, similar to scientists.

Holman (2017, p.6) suggests that "experimentation gives science its identity" and "science uses experiments to discover the realities underlying the world, and this practical approach seems to be as intrinsic to young learners as it is to professional researchers". Whilst experimentation is often associated with laboratory-based activities, it also plays an important part in primary science, with value being placed on the practical application of 'working scientifically' aspects within the 2014 National Curriculum (GB.DfE 2013). However, experimentation does not highlight the breadth of possibilities and opportunities which are encompassed in science. Hands on practical experiences include more than experimentation, for example illustrative experiences, investigations, surveys, basic skills and observations (Ward and Roden 2008). There is a consensus in the teaching community that "enquiry is at the heart of scientific activity" (Loxley *et al.* 2018 p.56) and forms the basis of scientific learning (Goldsworthy and Feasey 1997; Johnson 2005; Harlen 2015; ASE 2018b).

Within this thesis ‘scientific enquiry’ refers to a situation where curiosity provides the desire to find something out. This definition was informed by: Turner *et al.* (2011) who state that science enquiry is “what children do in order to answer scientific questions about the world around them” (page 11); Ofsted (2011) who suggest that it involves “exploring questions and finding answers through gathering and evaluating evidence” (p10); and the Association for Science Education (ASE) (2018b) who describe enquiry as “the processes and skills pupils should be taught and use, to find out more about the world and how it works” (p2). Within the primary National Curriculum (GB.DfE 2013), ‘working scientifically’ and the children’s skill of raising and answering questions is fundamental in the statuary guidance, therefore it is seen as central to scientific learning. The curriculum goals aim to develop children’s independence in answering their own questions as a result of children being “passionately curious” (Loxley *et al.* 2018 p.56); seeking information to answer their questions (Harlen and Qualter 2018); and generating new questions that can help them to link what they already know to new experiences (Chin and Osborne 2008). It is therefore essential that children learn about the nature, processes and methods of science, and “by working like scientists they will develop the skills to answer the questions that they raise” (Farrow and Strachan 2017, p.3).

Being ‘scientific’ draws upon an experiential approach to learning (Dewey 1938) and includes developing skills, attitudes and ways of working. It is a distinct way of knowing, doing and thinking (Wenham and Ovens 2010). It involves thinking about ideas, testing them against their experiences in scientific ways and comparing them with existing ideas and evidence (Johnson 2005; Harlen 2018). Outdoor and science learning connect well together to enable children to be scientific, for example, learning through observing decomposition, surveying growth, measuring the weather and testing forces in their natural environment is more beneficial and less abstract when it is in context. The importance of ideas and evidence within science can be understood as especially transferable to outdoor learning. Linking with the principles from Millar and Osborne (1998), science learning involves: developing a sense of awe and wonder; enthusiasm and interest; developing confidence and competence in engaging with scientific concepts; and developing ideas, explanations and procedures of scientific enquiry. These principles reveal the natural synergy between science and outdoor learning as well as highlighting the value of science in sustaining and developing children’s natural curiosity about the natural world around them.

Those who are science specialist teachers in primary schools see science as an important core subject (Davey 2021; Ofsted 2021). Two in three primary school teachers have not studied science beyond GCSE (Wellcome Trust 2017a) and even these non-specialist teachers are passionate about science underpinning everything that they teach. They believe that it is important to weave scientific concepts and enquiries throughout the topics that are covered. The more that children feel able to relate to science in their everyday lives, the better their engagement and progress (Godec, King and Archer 2017). In the same way, trainee teachers who choose to specialise in primary science commented on their positive experiences of teaching experiential science and how engaged and motivated the children were (Blackmore, Howard and Knighton 2018).

The Ofsted (2021) review is an important addition to this debate because it defines science as learning a body of knowledge relating to the products and practices of science. It states that by learning about the practices of science, children learn how scientific knowledge becomes established through scientific enquiry. However, Ofsted (2021) puts emphasis on the use of practical science to consolidate learning and aid vocabulary recall, rather than providing the possibility of applying vocabulary with a purpose which is one of the ten issues in primary science identified by Bianchi, Whittaker and Poole (2021).

Ofsted (2021) is concerned with the need to learn a wide range of vocabulary over time and that ‘fun’ activities do not enable deep understanding of science concepts or retention in children’s long-term memory. In contrast, outdoor science learning highlights the place of thinking scientifically within practical science, as its focus is on curiosity, scientific interests and questions. It is valuable for enabling motivation, drawing on prior learning and providing repeated and regular science experiences (Waite 2017). Both teachers and trainees understand the need to ensure uncertainty is welcomed in science and can be used positively to challenge ideas and thinking as well as inspire children to see science as more than knowledge and facts (Hoath 2020). Hoath (2020) also suggests that uncertainty yields new discoveries, some answers and more questions.

1.4 What are the issues in primary science education in England?

One of the most fundamental reasons that we teach science to children in English primary schools is to enable children to develop as individuals and to contribute to the needs of society. According to Serret and Earle (2018) it is important to provide opportunities for children to make sense of the world around them, equip themselves with vital life skills and make informed decisions. These opportunities form the foundation for their 'Science Capital' which constitutes science related knowledge, skills, attitudes and experience and demonstrates how people engage with science. It is benefitted by having an enquiring mind and enthusiasm (Archer *at al.* 2013).

There are several key issues in primary science education which limit the development of children's 'Science Capital'. Bianchi, Whittaker and Poole (2021) highlight a number of these issues relating to the learning including the lack of: curiosity, interest and questions (Holman 2017; Wellcome Trust 2017a); purpose (Holman 2017; Abrahams and Reiss 2010); and child-led autonomy and independence (McCrory 2017). Each of these represent the reality of current children's science learning experiences in English schools through the examples from primary science specialists and emphasises the decline in children's practice-based understanding. Effective outdoor science learning has the potential to negate these issues through the child-led opportunities that are fundamental to this approach.

In terms of children's attitudes to science education, there are negative perceptions about science being hard and, as a result, some children are less likely to recognise the broader value of science or continue to study it beyond GCSE statutory requirements, according to a survey of 209 primary schools in England (Wellcome Trust 2014). This interest in science appears to differ with age, with the Wellcome Trust survey (Wellcome Trust 2019b) suggesting that younger pupils in year 3 (age 7-8) appear to like science more than older pupils in year 6 (age 10-11) (53% as opposed to 34% like science 'a lot').

Children need to be invested in the learning in order to make progress, develop their scientific thinking and give them a purpose. Children's natural affinity for science learning will have been influenced by their school experiences and, according to Harlen *et al.* (2010), children are widely reported as finding their school science not relevant or interesting to them. They are lacking awareness of links between their science activities and the world around them, so do not see the point of studying things that appear to them as a series of disconnected facts (Ofsted 2011). Science learning is a discipline which is compatible with children's curiosity but if it is packaged in ways that are unrelated to the real world, it can appear abstract and unconnected to children. This is the problem that my research is addressing. Using the outdoors can make the learning even more relevant and help children to be 'rooted in' and more 'connected to' the concrete experiences from which the learning should be built.

Successful science is also about *how* the science is taught which, if it is taught in an abstract way, can lead to the disconnection of pupils from learning (Wellcome Trust 2005). When it is done well, for example through 'working scientifically' (GB.DfE 2013), there is an impact on children's interest and engagement in science. Extending investigations and greater learner autonomy provide increased challenge and stimulation (NESTA 2006, Osborne and Collins 2000) and the best teaching sets out to "sustain pupil's natural curiosity, so that they are eager to learn the subject content as well as develop the necessary investigate skills" (Ofsted 2013 p5). When is it done less well there is disconnection, the learning is superficial and lacks depth. According to Bianchi, Whittaker and Poole (2021), teachers align success in science with vocabulary recall and there is an overload of science with age-inappropriate terminology. This disconnect also occurs when being 'hands on' dominates being 'minds on' and when teachers are working harder than the children through abstract 'recipe' style tasks (Abrahams and Reiss 2010). The challenge for teachers is to make the learning interesting, relevant and of use for the rest of their lives within the enormous range of Science Technology Engineering and Maths (STEM) based possibilities. This can be problematic when teachers' professional autonomy is restricted as a result of government policy.

1.5 What is the impact of governmental policy on learning in the context of primary science?

The influence of government led priorities on practice has impacted upon the learning of science in primary schools. Since the government's removal of the end of Key Stage two testing (for 11 year olds), a survey from the Wellcome Trust (2011, p.1) found that teachers in England reported: "less teaching time devoted to science; change to the status of science; science assessments not done; reduced curriculum or coverage of the curriculum". The tests narrowed the learning by focusing on outcomes, yet the removal of the tests lowered its status and time given to science (Earle and Turner 2020). The 'state of the nation' report in 2017 also stated that children in younger year groups in primary education received fewer hours of weekly science lessons and only 30% of respondents said that their senior leaders saw science as very important compared with English (83%) and maths (84%) (Wellcome Trust 2017b; Wellcome Trust 2019a). In the maintaining curiosity report (Ofsted 2013), half of schools no longer see science as a priority and decision making about improving the teaching of primary science is ad-hoc and not strategic. The impact of this perceived lowering of the status of science can be seen in the evidence from the Key Stage two science sampling results. The data from 2016 (STA 2017b) showed that 23 percent of 11-year-olds were performing sufficiently well in science. This was down from 28 per cent in 2014 (Robertson 2017) and significantly lower than 53% of children who reached the expected standard in English and maths in 2016. This literature suggests that less science is being taught due to the profile being lowered, differences in assessment and schools not being accountable in the same way, which can impact on children's access to science and their attitudes towards science.

Another reason that science can lack priority in schools stems from the way that Ofsted tends to validate government expectations for schools and areas of priority are focused upon within their reports. Through Ofsted's inspections of schools in 2016 and 2017, 48% of Ofsted reports mentioned science and only 15% of reports mentioned the terms investigation or experiment, whereas 99% of reports mentioned maths (Wellcome Trust 2018). However, the schools with the highest or most rapidly improving standards ensured scientific enquiry was at the core of their work in science (Ofsted 2011). Through the introduction of the 2019 Education Inspection Framework (Ofsted 2019e), teachers are now expected to focus more on the substance of education and a broad curriculum including the prioritisation of Physical Education and Maths Mastery (EEF 2015; Newell 2019). The practical aspect that underpins Physical Education and Maths Mastery, which includes mathematical thinking and 'intelligent practice' (NCETM 2017), support children to develop deep and sustainable knowledge. Both practical approaches lead learning away from a knowledge-based curriculum and promote greater teacher autonomy. This is important in the context of this research because it may enable teachers to see the importance of practical learning and may promote the idea of thinking scientifically. It could have a positive impact on the quality of science learning through the shift in emphasis on the wider scientific attributes within the 'quality of education' judgement (Spielman 2018).

Despite this change in governmental approach, there still remains a disconnect between the requirements of teachers and the needs of children in practice, which is that *what* teachers are expected to teach is not meeting the needs of the children. As suggested by Galton and MacBeath (2008), the government continues to put ever increasing pressure on teachers to prove themselves against best practice ideals and criteria effectiveness (NEU 2018). Whilst the government have acknowledged the unnecessary workload issues for teachers (GB.DfE 2019b), they continue to inspect schools with a focus on grading the quality of educational intent, implementation and impact, including achievements in tests (Ofsted 2019e). This intensification of workload is as a result of pressure to raise standards, resulting in a lack of professional autonomy, creativity and sense of ownership. The post pandemic 'recovery curriculum' (GB.DfE 2021c), which predominantly focused on English and maths, had a negative impact on science, with 21% of schools prioritising other subjects over science, even though 67% reported gaps in children's science knowledge and skills (Wellcome Trust 2021).

In terms of learners, it has been acknowledged by Shernoff and Csikszentmihalyi (2009) that the learning needs to be relevant and connected, whilst rooted in concrete experiences with greater autonomy and opportunities for learning to be led through curiosity. However, according to Earle (2018), teachers can become reliant on statutory structures and pre-defined progression within the learning which do not value the importance of eliciting children's ideas. This has been intensified by Ofsted's changing position on learning in science. In 2008 Ofsted (2008b) questioned schools' over-emphasis on facts at the expense of investigations; involving the narrowing of the curriculum and a reliance on worksheets. It found that children's interest and enthusiasm in science was low, with Ofsted (2011) suggesting that the most important focus for schools was to ensure that pupils were engaged and challenged by their work in science, particularly in scientific investigation. However, in 2021 substantive knowledge became prioritised over disciplinary knowledge (Ofsted 2021) which is again creating a reliance on facts within school through the promotion of the importance of recall, retrieval and retention (Ofsted 2019b; GB.DfE 2019a).

1.6 The research questions

A lack of research focusing on the *learning outcomes*, *quality of learning* and *impact of this learning* on the children's attainment demonstrates a gap in knowledge and practice within outdoor science. As previously discussed, the outdoors is well placed to enable science learning to occur, where science is put into action and where it encourages active engagement based on real-world experiences. However, the take up to enable these changes has been limited by wider curriculum pressures and the restricted professional autonomy that teachers reportedly face (Worth and Van den Brande 2020). This research intends to equip practitioners with examples to help them engage with the outdoor learning for science pedagogical practices by validating the quality of the learning. Working alongside trainee teachers, who are science specialists and are uniquely positioned to observe and engage with the learners in small groups, provides the opportunity to gain novel insight into the children's learning.

Much of the available literature relating to outdoor science (Glackin 2016; Marchant 2019) focuses on the professional perceptions and confidence of teachers in teaching science whilst utilising the outdoors and does not focus on the learning outcomes or quality of learning. In order to validate outdoor scientific learning and to prove quality learning is occurring, there is a need for examples to highlight the value of the learning, academic gains and progress. As opposed to teaching abstract concepts, the use of the outdoor context provides a place for contextualised and connected learning. It also promotes scientific thinking through the use of evidence and ideas, which connect to scientific attitudes and attitudes towards science. The credibility of outdoor learning, along with the status of science as a core subject, are often questioned in practice and facts are frequently taught at the expense of enquiry. This emphasises the need for justification of the importance of enquiry within children's learning.

These issues inform the research aim and the research questions. The aim of this research is to 'understand what constitutes effective outdoor science learning' through exploring how trainee teachers can use the ethos and practice of outdoor learning to support children's engagement and learning in primary science. The research questions are based upon the assumption that science learning is occurring in all primary schools and that progression is something that can be defined and identified in practice. The subsidiary questions provide a skeleton around which to find information to answer the main research question.

Main question:

- How can trainee teachers most effectively support children's learning in primary science, using the outdoors?

Subsidiary questions:

- In what ways can children be encouraged to think scientifically through utilisation of outdoor learning?
- What scientific attitudes are demonstrated by the children when learning in the outdoors?
- How can trainee teachers gauge children's attainment and progress in outdoor science learning?
- What are the challenges associated with assessing children's practical science outdoors?

1.7 Outline of the thesis

The aim of this thesis is to understand what constitutes effective outdoor science learning. It explores how trainee teachers can use the ethos and practice of outdoor learning to support children's engagement and learning in primary science. The research questions focus on scientific thinking, attitudes, assessment and progress within the learning. These are addressed through the evidence of learning collected by three trainee teachers, who were science specialists, across three case study schools.

The thesis explores the literature associated with pedagogical issues in primary science, assessment of science and outdoor science learning. It examines the current position of primary science within the ever-changing academic and political landscape of education. It also provides an epistemological framework for the research focusing on experiential learning and considers and associated approaches to pedagogy.

The research paradigm, methodology, methods and ethical stance, including both ethical issues and ethical considerations, are viewed from an interpretivist lens and consider the nature of knowledge from a constructivist perspective. Theoretical and philosophical underpinnings are considered and the appropriateness of a multiple-case study approach for this research is examined and critiqued, with elements of subjectivity, power and validity discussed. Along with the suitability of documentary analysis, observations and interviews as the data collection mechanisms for evidencing and reflecting on outdoor science learning in-the-moment.

The approach to data analysis is set out in four stages from immersion through to higher level synthesis. Within the analysis and discussion of the findings, three main themes are identified across the three case studies. These focus on thinking scientifically, behaving scientifically and questioning scientifically, and then the findings are summarised and reflected upon. The findings are contextualised and considered in relation to the literature, policy and practice, then evaluated in light of the research questions. Methodological and ethical limitations are considered and implications for trainee teachers, professionals and my own professional practice are explored. It is acknowledged that trainee teachers can use the outdoors to facilitate science attainment, capture progress and identify higher order learning. The research tools are valuable in capturing evidence of outdoor science learning and provide a response to the ten key issues in primary science learning identified by Bianchi, Whittaker and Poole (2021). The issues that were particularly relevant within the context of my research focused on the purpose and progression in learning, children’s attitudes, questions, child-led autonomy and independence.

Literature review

This literature review can be broken down into three elements:

- pedagogical issues in primary science,
- the assessment of science learning and
- the science associated with outdoor learning.

They relate to the gaps in knowledge, the gaps in practice, and the subsidiary research questions associated with 'What constitutes effective outdoor science learning?'. This research links to a theoretical framework that is underpinned by the cognitive form of constructivism, associated with the internal workings of the mind (Hayes 2005). The literature review draws upon the work of a number of seminal theorists such as experiential learning from Dewey (1938) and Kolb (1984) as well as cognitive development from Piaget (1978) and Bloom *et al.* (1956) along with Zimmerman (1989) and Quigley, Muija and Stringer (2018) who explore self-regulation and metacognition.

The literature review is influenced by leaders in the field of outdoor learning such as Dillon *et al.* (2005), Waite (2011), Glackin (2013) and Hoath (2015). It is also informed by primary science research findings from Harlen (1985), Osborne, Wadsworth and Black (1992) and Bianchi, Whittaker and Poole (2021).

Pedagogical considerations for primary science

2.1 The progression of science in the curriculum

If science begins with a child's very first acts of exploration (de Boo 2000; Johnson, Christie and Wardle 2005; Watts, Salehjee and Essex 2016), this suggests that the activities which lead children to be spontaneously curious are likely to be intrinsically scientific. The current Early Years Foundation Stage (EYFS) (GB.DfE 2021b) curriculum includes 'Understanding the World' as a specific area of learning for children from birth to five years of age. The statutory expectations on practitioners to assess the children's attainment of Early Learning Goals include criteria for 'The Natural World' (GB.DfE 2022a). The content includes exploration, knowledge of similarities and differences, as well as understanding processes and changes. It draws on the children's experience and encourages children to talk and describe their observations and understanding. This is expanded upon in the non-statutory guidance of development matters (GB.DfE 2021a) but birth to 5 matters (Early Education 2021), which is non-statutory guidance created by the sector, goes further and recognises investigations, scientific enquiry and exploration as essential components of learning.

The key features of primary scientific enquiry, for children from five to eleven, are included in the National Curriculum (GB.DFE 2013) through 'working scientifically' which is defined as "understanding the nature, processes and methods of science for each year group" (p 145). In contrast to the EYFS (GB.DfE 2021b) curriculum, enquiry is embedded in the subject knowledge content of biology, chemistry and physics. In association with this definition, the characteristics of enquiry have been suggested to include: "observing over time; pattern seeking; identifying, classifying and grouping; comparative and fair testing; and researching using secondary sources" (p145). It involves children collecting, analysing and presenting data. It also supports future learning in KS3 (11-14 year olds) and KS4 (14-16 year olds) in more meaningful and sophisticated discussion of experimental design and control.

In the 'purpose of study' and 'non-statutory guidance' of the National Curriculum (GB.DFE 2013), emphasis has been put on experiential learning and simulating real-world environments so that learners can progress through applying their skills and practise the problem solving techniques needed for future employment. This learning may be "non-linear, informal and tacit" (Ofsted 2019c, p.4) but provides an opportunity for children to apply their science knowledge and enquiry skills in different contexts. Using an outdoor learning context that focuses on situated scientific learning, emphasises the relevance of experiential learning (Lucas and Claxton 2010).

2.2 An experiential approach to scientific learning

First-hand experiences are underpinned by experiential learning theory. Dewey (1922) found that children learn by 'doing' and education should be based on real-life situations. He highlighted the importance of social interaction focusing on the ability of the individual to question through experience and interest. Dewey (1922) focused on understanding the depth of the experiences. He saw learning as a dynamic process and a transaction between the children and their environment. Later, Kolb (1984) suggested that children construct new knowledge through a cycle of experiential learning involving doing something to gain concrete experience, reflection, interpretation and practice. Kolb (2015) went on to explore this theory in practice considering transformational experiences and learning-centred educational innovation in light of his review of experiential learning theory (Kolb and Kolb 2022).

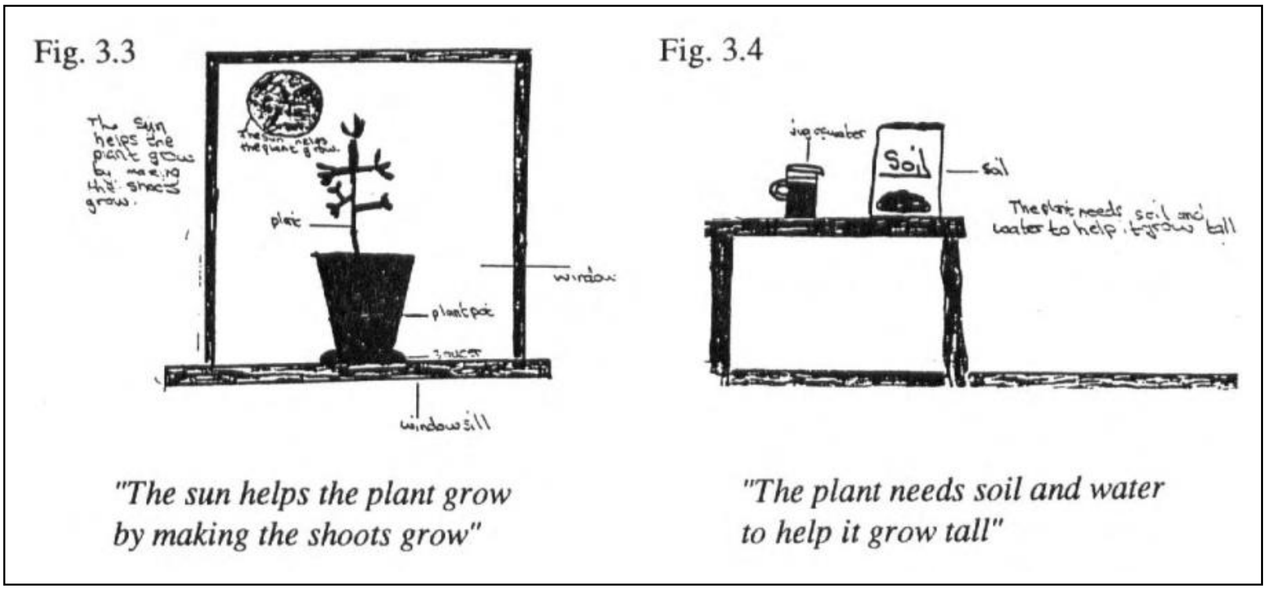
Whilst Kolb's (1984) model has been criticised for being too simplistic and not considering the contextual aspects of the learning process (Morris 2020a), when the learning was taken outdoors, the setting provided the concrete experiences that were contextually-rich and contextually-specific, which are both relevant to this thesis. Focusing on concrete experiences in nature, Leyshon (2020) places value on child-led learning, higher order skills and self-efficacy within experiential outdoor learning. Although her research focuses on children who were more able and talented, the outcomes of creativity, purpose and independence align with this thesis. There has also been a resurgence in experiential learning research focusing on creativity (Gabriel 2021) and self-directed learning (Morris 2020b). They recognise creative solutions are generated through the process of experiential learning and learners are also proactive in seeking information, demonstrating independence and retaining responsibility. In addition, this process has been associated with digital technology where the research critically considers the affordances of connectivity, accessing knowledge for greater child-centred learning and supporting reflection (Hills and Thomas 2020). Whilst recognising the value of digital technology to support children's science learning, it was useful to bear in mind the challenges associated with managing the distraction that devices provide and ensuring discovery learning is protected (Hills and Thomas 2020).

Dewey (1922) suggested that children create understanding through making sense of the world around them. This underpins the current experiential approach to learning in science within the EYFS (GB.DfE 2021b). It is also reflected in the teaching of science in the primary National Curriculum (GB.DFE 2013) which involves ensuring that children from 5 to 11 years of age are at the heart of the learning, with the emphasis being on their ideas (CASE 1967; Bell and Darlington 2018). As the children get older, the nature of science becomes more reliant on a combination of both the knowledge about scientific activity and the knowledge of scientific thinking. There is still an element of ambiguity based on how to teach these effectively (Sharp *et al*. 2017). Without knowing how ideas were developed, learning science would require blind acceptance of many ideas about the natural world. They appear to run counter to common sense and conflict with everyday knowledge (Ofsted 2021); such as accepting that the Earth is round, when intuition suggests that it is flat (Allen 2019), or in terms of inertia and accepting that objects in motion will carry on eternally if unperturbed, when intuition suggests that every object in motion seems destined to slow down (Harlen *et al*. 2010). Ofsted (2021) acknowledge that children need to know why their scientific idea is incorrect and why their misconception from prior knowledge is scientifically wrong, highlighting the value of of metacognition. Repeated opportunities in a range of contexts to practice activating the scientific concepts while suppressing the misconception. Exposing children to specific conflicts to apply conceptual knowledge.

Ideas about the world are used to understand or explain what has been experienced. The phrase 'Ideas and evidence' was used in the previous curriculum (GB.DfEE 1999), suggesting that 'thinking scientifically' was at the heart of science itself. There is now an expectation that 'working scientifically' (GB.DfE 2013, p.24) needs to be demonstrated in the current curriculum, with some upper Key Stage two (9-11 year olds) learning outcomes being more closely aligned to a 'thinking scientifically' approach, for example exploring and justifying ideas, identifying patterns and making decisions (CIEC 2021).

In line with the approach within this thesis, the following research studies demonstrate how experiential learning is central to science learning. They highlight examples of learner generated knowledge and understanding, reflect on learning and explore ideas that children hold about the world around them. However, examples from the outdoors are limited and progression is under-discussed.

The science processes and concepts exploration project, between 1990-1998, was a study of the ideas of primary school children with the aim of being able to identify, justify and validate the quality of the experiential learning that was occurring (Osborne, Wadsworth and Black 1992). It provided examples of children's ideas and common misconceptions in relation to abstract concepts, such as evolution, energy and forces, through representations in the form of children's drawings and their discussions (Figure 1). It focused on knowledge as opposed to enquiry skills and supported teachers to understand children's cognitive thinking, enabling them to anticipate the support children might need. Whilst experiential learning was central to the project, it did not include a focus on outdoor specific examples, although some could be seen as relevant to the outdoors (Figure 1), including the concept areas of processes of life, growth and weather. The project was not progressive, nor did it focus on age appropriateness, emphasising teacher understanding rather than promoting metacognition and giving children the ownership of their learning.



"The sun helps the plant grow by making the shoots grow"

"The plant needs soil and water to help it grow tall"

<u>Figure 1:</u> SPACE Nuffield resources, p20. [1]

More recent examples of experiential learning in primary schools include the Teacher Assessment in Primary Science (TAPS) project (PSTT 2015; Earle 2018; PSTT 2021), the government's teacher assessment exemplification (STA 2018a) and Planning for Assessment (PLAN) (ASE 2018a). They provide lesson plan examples and annotated evidence of learning by year group, acting as a benchmark for teachers to judge the pitch and expectations. However, whilst experiential learning is central to the assessment examples, the reliance on written recording doesn't fully demonstrate the extent of the learning (Figure 2). There is also a lack of outdoor learning and, where they are included, the examples do not capture learning in-the-moment. Assessment of scientific thinking is incorporated in the occasional examples of talk in the PLAN resources (ASE 2018a) which have the potential to be developed further (green text in Figure 2). In summary, although outdoor learning was not prominent in these studies, the children were at the heart of the research with the aim of understanding the experiential learning to improve practice.

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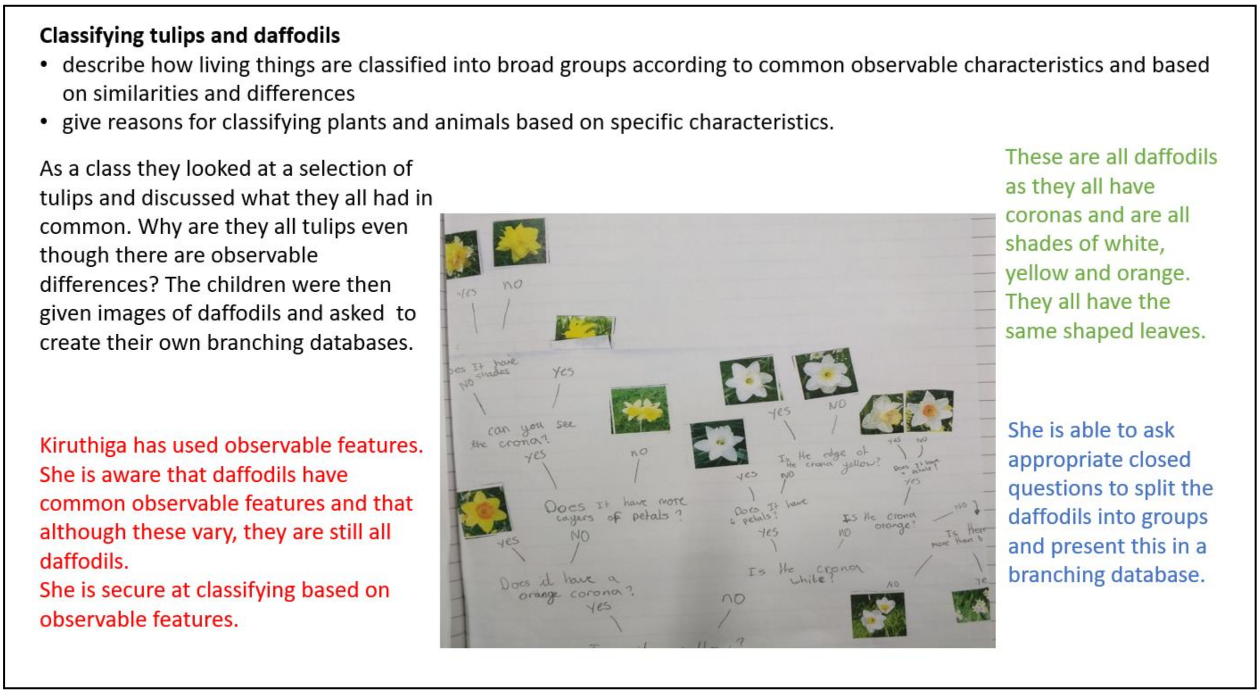

Classifying tulips and daffodils

- describe how living things are classified into broad groups according to common observable characteristics and based on similarities and differences
- give reasons for classifying plants and animals based on specific characteristics.

As a class they looked at a selection of tulips and discussed what they all had in common. Why are they all tulips even though there are observable differences? The children were then given images of daffodils and asked to create their own branching databases.

Kiruthiga has used observable features. She is aware that daffodils have common observable features and that although these vary, they are still all daffodils.
She is secure at classifying based on observable features.

These are all daffodils as they all have coronas and are all shades of white, yellow and orange. They all have the same shaped leaves.

She is able to ask appropriate closed questions to split the daffodils into groups and present this in a branching database.

Figure 2: PLAN resources (Kiruthiga example, ASE 2018a). [2]

Despite these benefits of experiential learning, there have also been criticisms of the approach. Firstly, the emphasis on child-led learning, rather than a didactic approach involving the transition of knowledge, has been criticised because of a perceived lack of structure, rigour and challenge (Ofsted 2021). Yet, greater benefit has been found to come from decision making, evaluation and accepting uncertainty as a result of experimental learning (Kolb 2015; Scogin *et al*. 2017; Coker *et al.* 2017). It has also been stated that the actual hands-on components of experiential learning are not always the most important parts (Wenning 2011). It could be suggested that all enquiry activities are experiential, yet not all experiential activities constitute enquiry. However, ensuring the science enquiry skills are embedded in the learning is a key component of the teacher's role and therefore a focus for the trainees within this research.

Secondly, much of the enquiry process occurs both before 'doing' the hands-on as well as after through 'evaluation'. There is value placed on the ideas, choices and arguments which underpin science learning. However, using experiential components

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does not always provide opportunities to initiate and develop these aspects (Erduran and Dagher 2014; Osborne 2015; Bianchi, Whittaker and Poole 2021). Ensuring these pre- and post-learning processes occur are important in maximising the learning opportunities and enabling metacognition within this research.

Finally, the experiential learning approach is not valued by the government because the National Curriculum (GB.DFE 2013) provides a limited range of enquiry characteristics within the programme of study statutory requirements that relate to outdoor learning and experiential learning. This has the potential to restrict the scientific learning possibilities because there have been many more characteristics of enquiry identified through research (Isaacs 1962; Cross and Bowden 2014; Dunn and Peacock 2015). Within this research, the trainee teachers need to use professional autonomy to go beyond the non-statutory notes and guidance to maximise the learning potential of the outdoor context. Enabling outdoor science learning through these experiences provides valuable opportunities to connect with science-in-action and appreciate scientific knowledge in concrete contexts. This supports Dewey's (1922) view on valuing the context of the learning and promoting the use of outdoor settings to build up worthwhile experiences.

2.2.1 The role of the adult in experiential learning

In an experiential approach, the role of the adult is one that guides children through the process of learning and personal reflection, resulting in positive learning outcomes associated with the cognitive content of the minds of individual learners (Jenks and Murphy 1979). Dewey (1922) believed in the legitimacy and value of experiential approaches to learning, as a result of continuity and interaction. Experiential learning was an important part of Kolb's (1984) learning cycle model, which had an emphasis on the adult facilitating and observing in order to support the progression of an individual. Rather than the transition of knowledge, the role of the adult was to guide the children to make connections and develop critical thinking skills, to challenge misconceptions and ideologies in order to prevent reinforcement of misunderstandings. Within the experiential approach of this thesis, there was an expectation that the adult would manage knowledge and skills, questions and have an awareness of attitudes. When teaching science through an experiential approach, the teacher plays a pivotal role, which involves teaching the enquiry skills as well as the scientific concepts. An issue affecting current practice is that experiential learning can be perceived by the teacher, in the role of a facilitator, as more ‘chaotic’ especially when the teacher believes they have less control of the decision making (Rogers 1994). However, it needs to be acknowledged that this is an active process that requires an organised approach (Smith 2016). This organised approach is something that this thesis aims to support.

The role of the adult within experiential learning is to personalise the learning to enable the learner to have control of their own learning. Giving children the ownership of their learning to enable them to demonstrate their understanding (Goswami and Brown 1989; de Bóo 1999; Cross and Bowden 2014; Peacock *et al*. 2017) can be seen as integral to children developing their scientific literacy. Established scientific thinking is said by Kuhn (2011a) to involve metacognitive and meta-strategic knowledge which is where children reflect upon both the process of knowledge acquisition and the changes that result from engaging in scientific activities.

In order to affect metacognitive change, teachers need to encourage children to regulate their cognition and learning. Self-regulation refers to the degree to which children are metacognitively, motivationally and behaviourally active participants in their own learning process (Zimmerman 1989). Metacognition has been proven to have positive impacts on students’ academic outcomes, self-efficacy and intrinsic motivation (Kitsantas 2002; Zimmerman 2000). It enables deep learning rather than superficial learning, which was commented upon as an ‘issue’ in English education by Bianchi, Whittaker and Poole (2021), and evidenced as effective practice in relation to outdoor learning (Schraw 2012).

When the learning is taken outdoors, it moves away from the more typical classroom demonstrations to progressively greater freedom, resulting in improved outcomes because of greater independence, self-awareness, choice, uncertainty and the development of metacognition (Zimmerman and Schunk 2001). Child-led learning is a key aspect of outdoor learning and so securing a balance between control and intellectual sophistication is important. Wenning (2004) suggested that when the child has more control of the learning, the intellectual sophistication will increase. When the adult enables metacognition, the children understand how they learn, whilst taking control of their own learning (Quigley, Muija and Stringer 2018).

Although there are a range of models, three are most relevant to this thesis because they examine the experiential approach to science enquiry and understand the need for a child-centred approach, alongside the need for a degree of teacher intervention. These include:

- Vygotsky’s (1978) scaffolding theory,
- Bybee and Landes (1990) 5Es model,
- Wenning’s (2006) inquiry spectrum.

Vygotsky’s (1978) ‘scaffolding’ theory involves a well-balanced combination of *structure* for open enquiry learning and sufficient *space* for independence within experiential learning. The teacher supports the child to solve a problem, carry out a task or achieve a goal which would be beyond their unassisted efforts. It requires specialist knowledge and a personalised approach to know each child’s ‘zone of proximal development’.

Bybee and Landes (1990) 5Es model of instruction consists of five phases of instruction within the learning cycle including: engagement, exploration, explanation, elaboration and evaluation. There is an increasing level of sophistication within this model, which aligns with the emphasis on progression within this thesis, but it has been criticised for a lack of critical thinking and is seen as time consuming (Bybee *et al.* 2006).

Wenning (2006) proposed a scientific enquiry model which concentrated on inquiry (enquiry) as a spectrum. The levels of enquiry demonstrate the hierarchy of enquiry-oriented science with developing intellectual sophistication and locus of control between the teacher and the learner. Whilst it acknowledges the importance of the teacher, this model emphasises the hierarchy of enquiry teaching towards the higher levels of intellectual sophistication when there is greater control for the learner. This was supported by the findings from Serret *et al.* (2017), who found that when more open-ended enquiries were introduced, through greater adaptation and contextualised approaches, the teachers were better able to meet the needs of the class. There are also criticisms of the spectrum, such as when the level of control that is given to the learner results in a discovery-based approach to enquiry. For example, when the learning is expected to ‘emerge’ from observations or measurements (Solomon 1994). Without the scaffolding from the teacher within experiential learning, the children are not supported to make connections and see the phenomena in a scientific way (Abrahams and Millar 2008).

All of these models use an experiential approach centring around direct experiences, knowledge discovery that has meaning, and is where children are committed to and have control of their own learning (Moon 2004). For this to be effective in this research and in the outdoors, the teachers' scaffolding and assessment of experiential learning needed to be personalised according to the learners needs. However, they are deemed to be time consuming and require flexibility to be applied in the context of the trainees' placement schools.

2.2.2 Balancing the acquisition of knowledge with the development of enquiry skills within experiential learning

The nature of science can be understood to involve the separation of *'knowledge of scientific ideas'* from *'knowledge about scientific enquiry'* (Harlen 2018; Lederman and Lederman 2020). Termed by Ofsted (2021) as 'substantive knowledge' and 'disciplinary knowledge' to infer both conceptual 'know that' and procedural 'know how' learning, they were put in place to address ambiguity and strengthen clarity of learning goals across all curriculum subjects. These definitions demonstrate an ambiguity around how to teach both 'ideas' and 'enquiry' effectively in science (Rönnebeck, Bernholt and Ropohl 2016; Sharp *et al.* 2017).

Science can also be separated into its component parts, taking an atomistic approach, where the acquisition of knowledge is prioritised (Earle 2018). The ASKIS project demonstrated an atomistic approach in the way they broke down enquiry into smaller skills (Goldsworthy, Watson and Wood-Robinson 2000; Coates and Wilson 2003; CIEC 2021). Value was placed upon more direct and explicit teaching of the skills, although, according to Millar (2010), skills are seen as 'strongly content dependent'. Therefore, rather than teaching the skills in isolation, there is a value in teaching them *in situ* for them to be applied and be seen as purposeful (Young 2013). Experiential learning enables the application and purpose with choice, uncertainty and problem solving underpinning the approach as opposed to memorising and recalling instructions. This approach results in children improving their ability to remember knowledge over time, apply knowledge in different contexts and develop the kind of knowledge that facilitates further learning (Wheelahan 2012).

Additionally, enquiry skills can be seen as "inseparable in practice" (Harlen 1999, p.129) from the conceptual context in which they are applied. This is reflected in the National Curriculum guidance: "it is also vitally important that they develop secure understanding of each key block of knowledge and concepts in order to progress to the next stage. Insecure, superficial understanding will not allow genuine progression." (GB.DfE 2013, p.144). Therefore, for the learning to be memorable, it is important for understanding to be embedded and the children to have ownership of the learning, ensuring that what shaped the content and made it memorable, such as the context and experience, are maintained. Having an element of choice and control of the learning empowers the child and increases motivation, thereby promoting self-efficacy, autonomy and genuine progression (Bandura 1997).

2.2.3 Children's scientific questions within experiential learning

In primary schools there is often an over-reliance on investigations in science (Goldsworthy, Watson and Wood-Robinson 1998) and less emphasis on children's independence and confidence in raising their own questions (Eick 2012) through experiential learning. Exploring children's questions is key to developing scientific processes (Cutting and Kelly 2015), where children use questioning to plan, prioritise, analyse and communicate findings, in response to their own questions. Children raise questions when faced with a knowledge gap and want to extend their understanding, leading to the development of new knowledge (Scardamalia 2002, Peacock *et al.* 2017). In doing so, they are demonstrating metacognition by actively taking ownership of their questioning (Burgh, Gillies *et al.* 2012). Questioning supports children in finding out more and constructing scientific ideas (Allen 2019; McCrory 2017). Children should be encouraged to ask questions about the world around them (Ward and Roden 2016), enabling them to integrate new knowledge with their pre-existing ideas, thereby demonstrating their investment in an aspect of the real world and ensuring the learning is meaningful.

Teachers can use children's questions to evaluate their thought process and understand the learning (Sutama *et al.* 2018). They can identify their misconceptions when children articulate their questions (Chin, Brown and Bruce 2002) and modelling of questioning has resulted in greater success when children design their own enquiry questions (Cuccio-Schirripa and Steiner 2000). Higher order questions enable children to reason, interpret or describe their own first-hand observations of their environment (Hapgood *et al.* 2004). Yet, higher order questioning in science is rare (Braund and Leigh 2012; Harlen 2001) because they are reliant on a high level of critical thinking (Wimer, J. *et al*. 2001; Chen, Hand and Norton-Meir 2017). Teachers need the required pedagogical knowledge and confidence to scaffold, model and identify the use of higher order questioning (Murphy and Beggs 2005; Hudson 2007), in order to develop critical thinkers (Zhai, Jocz and Tan 2014) and enable critical understanding (Wimer, J. *et al*. 2001).

There are a number of studies that have classified questions with the intention of supporting trainee teachers and teachers to develop higher order questioning, three of which are relevant to this research. Jelly (1985) focused on how teachers should respond to different classes of questions but this was not seen to be progressive. Children's questions were classified in one of five ways: i) comments as questions, ii) philosophical, iii) facts, iv) complex and v) investigable. Goldsworthy and Feasey's (1997) suggested ways of sorting a range of investigative questions through the best way to find the answer. Examples include: questions that tell us what to change and what to measure, questions that tell us what to change but we have to decide what to measure, questions that tell us what to measure but we have to decide what to change, and finally, questions were we have to decide what to change *and* what to measure. The latter being acknowledged as the more sophisticated and higher order questions. Murphy, Gripton and McEwan (2021) explored progressive questioning based on Taggart and Wilson's (2005) reflective thinking pyramid, where questions move the children's thinking from simple to complex and structured to open-ended, including questions that involve connections, reasoning or are hypothetical. These show the range and scope in the classification of children's questions within experiential learning and the emphasis on the responsibility for the learning shifting between the adult and the child.

Teachers should use children's interest in the outdoors to engage them further in science through contextualisation (Hardman and Luke 2016) and experiential learning (Dewey 1922). Learning in context supports spontaneity and exposure to scientific phenomena (Russell and McGuigan 2016) and outdoor learning can help to elicit children's questions through providing freedom and opportunities for independent thinking (VanZee *et al*. 2001; Gillies 2014). Sensory experiences, while learning in the outdoors, provide valuable opportunities for children to raise questions (Grimshaw *et al.* 2019), problem solve (Dillon *et al.* 2005; Waite 2017) and take ownership of their learning (Soh and Meerah 2013; Lieflander *et al.* 2013; Barnett and Feasey 2016). Taking a more child-led approach to learning like this can encourage children to ask questions and make predictions based on their curiosity (Brunton and Thornton 2010; Harlen and Qualter 2018; Sharp *et al.* 2017). Attitudes such as inquisitiveness, imagination and creativity have also been found to stimulate questions (McCrory 2017; Smith 2016; Ofsted 2013) and are beneficial to learning in science.

Being outdoors is essential in stimulating children's natural curiosity and provoking questioning (Knight 2013; Putri and Arty 2019). It offers a safe place to talk (Godemann and Michelsen 2011; Furtak *et al.* 2012; Cooley *et al.* 2020) and develop questions but is also a place where children are respected to share ideas and where they have the time and confidence to construct their questions (Barfod and Daugbjerg 2018). An in-depth understanding of the importance of children's questioning, and their categories, will enable educators to assess the learning more accurately and, in turn, support children's understanding and achievement when learning in the outdoors. Children's questioning is closely linked to their attitudes such as curiosity and provides opportunities for them to demonstrate motivation, confidence, independence and ownership of the learning.

2.2.4 Children's scientific attitudes within experiential learning

Attitudes are not explicitly referred to in the science curriculum, but with the new focus from Ofsted (2019e) including a judgement on 'behaviour and attitudes', this could alter practice in favour of the recognition of scientific attitudes. Within this, inspectors will consider the ways in which children demonstrate their attitudes and behaviours through the key characteristics of effective learning such as "being committed to their learning, know how to study effectively, are resilient to setbacks and take pride in their achievements" (p.10).

Arnson, Wilson and Akert (1994) suggest that attitudes can consist of three aspects: affective, cognitive, and behavioural. As with the subject knowledge and skills debate, Nundy (1999) highlighted the interconnection of, and the difficulties of distinguishing between affective and cognitive outcomes. Within science education, it can be divided into 'attitudes towards science', for example subject choice, and 'scientific attitudes', such as mind-sets about thinking in a scientific way (Gardner 1975). Harlen *et al.* (2010) provided a set of principles, as identified by an international group of scientists, engineers and science educators. They include principles relating to attitudes including nurturing and sustaining curiosity, as well as fostering attitudes of and towards science.

There have been a number of studies that examined 'attitudes toward science' in general (Ebenezer and Zoller 1993; Osborne, Simon and Collins 2010; Sheldrake, Mujtaba and Reiss 2017) many of them focus on beliefs and opinions rather than observable characteristics of 'scientific attitudes'. It is important to promote science as enjoyable in order to maintain a positive 'attitude towards science'. Motivation plays an important role in this (CBI 2015) especially in light of declining student engagement in both secondary and primary science, which has been a cause of concern for scientists and science educators for some time (Ofsted 2011). Falling enrolments and attitudes of secondary school pupils in England led to a research focus on attitudes towards science (Reid 2006). Which is common internationally (Osborne and Millar 2017) and is a concern not just for the UK.

Evidence from the field of neuroscience supports the argument that the first stage in learning is motivation (Collins 2015); brain imaging reveals how grasping new ideas is accompanied by an emotional reaction showing that there is pleasure in developing understanding. As suggested in learning using a Growth Mindset (Dweck 2012), persistence is a required state for most learning i.e. children need to practise, repeat, try again and continue to practise. In addition, exploration and investigation increase creativity and brain plasticity, which help children to become open to new ideas and be more creative in their own ideas (Collins 2015).

In order to 'catch' rather than 'teach' attitudes it is necessary to be able to articulate the types of 'scientific attitudes' that children use in primary schools. Jenkins (2006) characterised scientific attitudes into five elements. Similar to those identified by Harlen and Qualter (2018), these focused on critical mindedness, respect for evidence, honesty, objectivity, and open-mindedness. In addition, Kim *et al.* (2020) suggested curiosity, tolerance or uncertainty, perseverance, cooperativeness and creativity are also developed through primary science. These scientific attitudes are transferrable, meaningful and promote cognitive development. Scientific enquiry is 'crucial in developing and sustaining curiosity' (Smith 2016, p.6) which is one attitude that is significant within this research. Facilitating and promoting curiosity in science education is integral to the primary science curriculum (Ofsted 2013); being curious and creative is vital to scientific effort, with children seeing it as a never-ending journey of discovery.

Learning in the outdoors provides opportunities and resources to enable scientific attitudes. Much of the research focused on environmental attitudes related to discovery and exploration (Rios and Brewer 2014) but there was less on the more science specific attitudes in the outdoors. One exception was Kim *et al.* (2020) who analysed scientific attitudes in an outdoor context and found that the cotton project enabled children to improve their scientific attitudes as a result of using their senses, measurement, examining flowers and bulbs, and recording observations. This improvement was seen alongside their acquisition of scientific concepts through their active participation in nature, problem solving and self-directed learning.

Witt and Kimple (2008) found that young children have a strong curiosity regarding the natural environment, which they satisfy with hands-on learning. As can be seen in early years education where children are viewed as natural scientists due to their propensity for exploration and curiosity which underpin learning (Sobel and Letourneau 2018; de Boo 2000). Nature-friendly attitudes include respect and pursue coexistence with nature (Kang *et al*. 2012), leading to eco-friendly behaviours (Bamberg and Moser 2007). Kim *et al.* (2020) explored nature friendly attitudes which built upon the 'scientific attitudes' to include initiative and active engagement, respect, love and affection towards living things, preference toward the natural environment and nature conservation. Cheng and Monroe (2012) found that enjoyment of nature, empathy for creatures, sense of oneness and a sense of responsibility. These highlighted the importance of outdoor learning and the close connection it has with science.

2.3 The influence of scientific literacy on pedagogical considerations

To enable children to be scientifically literate as adults and improve their 'Science Capital' (Archer *et al*. 2015), it is necessary to develop enquiring minds through working scientifically, as well as thinking scientifically and behaving scientifically. Developing these dispositions involves moving beyond the boundaries of the National Curriculum (GB.DFE 2013) and developing attitudes that will motivate learners to have a love of science.

Zimmerman and Klahr (2018) refer to scientific literacy as the understanding required to investigate, evaluate and comprehend science content, processes and products. Scientific literacy enables the development of non-routine problem solving, adaptability, complex communication skills, self-management and systems thinking, which were seen by the American based National Research Council (USA.NRC 2010) to be the skills that are required for the 21st century workforce. Scientific literacy is needed for technological progress, improved health and well-being, economic gains and sustainability. It leads to social, environmental and economic benefits which are backed by the Horizon 2020 (2014) vision of a more enlightened knowledge-based society, within which there is a focus on recognising the importance of science in securing Europe's global competitiveness; hence the importance of acquiring 'Science Capital' (Archer *et al*. 2015).

2.3.1 Thinking scientifically

Scientific literacy encompasses the characteristics of thinking scientifically, which have been defined in a variety of ways. Lehrer and Schauble (2006) describe thinking scientifically as scientific reasoning. They expand by including logic, heuristics and strategies for "coordinating theory and evidence, mastering counterfactual reasoning, distinguishing patterns of evidence in relation to a conclusion or understanding the logic of experimental design" (p156). Zimmerman and Croker (2013) also relate thinking scientifically to reasoning and problem solving. However, Kuhn (2011b) builds on this with a focus on intentional information or knowledge seeking through the use of questioning, together with Williams *et al.* (2004) who suggest that 'Thinking Like A Scientist' involves questioning alongside problem solving, using evidence and reflecting. Within this thesis, 'thinking scientifically' has been defined as 'understanding the nature of science through the use of ideas to make decisions, solve problems, reason from evidence and ask questions about the real world'.

The relevance of thinking scientifically can be seen in a number of studies. The 'Thinking together' project (Mercer and Littleton 2007) included examples drawn from scientific interactions in classrooms which illustrated how children develop as thinkers, problem-solvers and effective members of collective endeavours. Findings from the 'Thinking, Doing, Talking Science' project (EEF 2019b), demonstrated that the approach had a positive impact on pupils' attitudes to science and practical work in particular. It highlighted strategies that aimed to encourage pupils to use higher order thinking skills and revealed an impact of 3 months' progress in children's learning outcomes. These studies were supported by research that found that inquiry and authentic problem solving encourage higher-order thinking (Conley, Douglass and Trinkley 2014; Yakman and Lee 2012) which reinforces the idea that thinking scientifically enables progress in children's learning outcomes.

Through the development of science literacy and thinking scientifically, children engage in an active interchange with others who share their interest resulting in social gains and academic advantages (Dillon *et al.* 2005). Dawes (2011) suggested that scientific enquiry can provide exciting contexts for children to talk about their findings. This allows children to develop their skills in explaining and interpreting results, in addition to reflecting and evaluating, therefore enabling them to 'Work Scientifically' (GB.DfE 2013). Opportunities for contextualised learning in the outdoors provide authentic possibilities for the development of children's ability to think scientifically. Recommendations from Dillon *et al.* (2005) focus on the freedom and quality of the experience including real-world contextualisation; well-informed approaches to the use of the outdoor classroom; individuals or groups doing something new or differently by learning from experience; and supporting learning and change with communities of learners. Through the development of communication skills, leadership, teamwork and social actions, children demonstrate gains which relate to 'Science Capital' (Archer *et al.* 2015) and this has the potential to affect their aspirations and involvement in science in their future.

2.3.2 Behaving scientifically

Scientific approaches to problem solving involve the use of behaviours including using prior knowledge, clarifying, being accurate, using trial and error, comparing and contrasting findings. Other behavioural approaches to decision making encourage “guess work, inspiration, correction, blind alleys, hypothesis testing, dead ends and backtracking” (Venables and Tan 2006 p123), risk taking and learning from mistakes (Ward and Roden 2016). These all contribute to the ‘scientific literacy’ of the learner, which has been referred to by Zimmerman and Klahr (2018) as the understanding required to investigate, evaluate and comprehend science content, processes and products.

‘Behaving scientifically’ has been defined in this thesis as ‘an action which enables scientific literacy’. This includes ways of working such as observing over time, identifying and classifying, as well as problem solving (Harlen and Qualter 2009). However, it goes beyond the enquiry focused actions of ‘working scientifically’ (GB.DFE 2013) and ‘disciplinary knowledge’ (Ofsted 2021) to include: approaches to decision making (Venables and Tan 2006 p123); questioning and being sceptical; being able to contradict our beliefs and personal biases; being open to change as opposed to accepting confirmation bias; taking risks; and finally learning from mistakes (Ward and Roden 2016).

Scientists deliberately and consciously behave in a way that children do naturally, instinctively and effortlessly (Smith 1978). This is reflected in the beliefs of The Gatsby Foundation (Holman 2017) which states that “practical approach to science seems to be as intrinsic to young leaners as it is to professional researchers” (p4). Demonstrating scientific attitudes and competencies such as curiosity, collaboration, scepticism, imagination, questioning and tolerance to uncertainty and so on (Smith 2016, Ofsted 2013). As children get older, they tend to lose the ability to learn through exploration and experimentation (Ward and Roden 2016). Life’s experiences, over time, can influence their open-minded approach and openness to multiple possibilities. There is value in their willingness to look for evidence that could lead to changing their minds (Cremin *et al.* 2015). Through enhancing learners’ curiosity, wonder and questioning, building on their natural inclination to seek meaning and understanding about the world around them, we can ensure that the attributes of scientists are not lost. This curiosity, wonder and questioning has been reported through outdoor learning (Dillon *et al.* 2005) and demonstrates a clear connection with the possibilities that are associated with behaving scientifically and learning outdoors.

Having the skills of ‘thinking’ and ‘behaving scientifically’ enhances children’s ability to make informed choices, to be responsible for decision making and realise consequences, which can all contribute to the social and life-long benefits of learning and prepare children for life (Education Act 2002). This relates to the PISA 2015 definition of scientific literacy which is the “ability to engage with science-related issues, and with the ideas of science, as a reflective citizen” (OECD 2016, p.20) and the UN (2016) sustainable development goals which aim to ensure children are able to become skilful members of society and citizens of the world.

The assessment of science learning

3.1 Teacher assessment in science learning and outdoor learning.

Schools are accountable for the progress that children make within science (GB.DfE 2022c). There is currently no statutory testing in science for Key Stage two and learning is largely measured through teacher assessment which includes pupil assessment, teacher assessment, moderation of judgements and summative reporting, all of which feed into the whole school assessment process (Nuffield Foundation 2012; Earle 2015). This was exacerbated in 2021 as a result of the pandemic by the fact that teachers did not even need to make or submit teacher assessment judgements for pupils in science (Ofsted 2020a; Ofsted 2020b). Although teacher assessment arguably increases the reliability of the judgement, it could lack validity when identifying how well science is being learned. Teacher assessment was seen to provide a balance between enquiry skills and recall of knowledge (Ward and Roden 2016). Rose (2009) recommended that teacher assessment would give a better sense of how children were doing in the subject, and would prevent the skewing of the science curriculum towards learning facts. Currently there is guidance for teacher assessment in science (STA 2018b) which sets end of Key Stage expectations for Science and English Writing. There is also minimal non-statuary guidance such as STA exemplification materials which are available for KS1 and KS2 (STA 2018a).

Whilst Assessing Pupil Progress (GB.DfE 2009) has been archived, the Association for Science Education (ASE) PLAN resources (ASE 2018a) have been produced to support teachers assessment judgements. Knowledge and working scientifically matrices provided additional guidance, annotated collections of children’s work demonstrated learning that met expectations. Teachers and subject leaders use these resources as a starting point from which to plan and assess but as they are not mandatory there are inconsistencies in practice between schools (Ofsted 2011). In a time sensitive environment teachers are at risk of relying on highly prescriptive and structured planning materials for support (GB.DfE 2016b). This highlights a gap in practice which further fuels the significance of this research. In order to help minimise these inconsistencies and provide guidance for schools in relation to scientific outdoor learning, this research will offer guidance for trainee teachers and other educators in assessing the children's learning.

The assessment of learning in science is difficult to quantify when focusing on practical science learning, which Dillon (2008) highlighted as being more abstract for the practical subjects. This is especially demanding when completed outdoors, as a result of the challenges associated with capturing and judging the quality of the learning. Black and Wiliam (1998) believed that children ought to be 'doing' science, such as exploring and forming arguments, which is not best assessed through a test, but through observation and teacher judgments. The moderation of these judgments can be defined as: "potentially the most effective strategy for ensuring both validity and reliability in teacher assessment" (Johnson 2013, p.99). These are important points to recognise in terms of endorsing both consistency of judgement and teacher understanding of the breadth of the children's understanding. Capturing the learning through observation can further strengthen the assessment judgements through the use of ipsative, norm and criteria referenced assessment methods (Gipps 1994, Lum 2015).

Experiential learning cycles (Dewey, 1938; Kolb 1984) highlight the importance of assessment but advocate that it is not a standalone element due to the need to plan for assessment and the need to feed forward into future planning (Black and Wiliam 2018; Earle 2019). The GB.DfE (2021b) suggested that formative teacher assessment informs EYFS teaching and has a crucial role in supporting pupils to progress and achieve their full potential. Considering the outcome, collecting the evidence of learning may not include individual progression but evidence of the attainment within the group over time leading to a signposting of the degree of success within the expectations that have been set. Progression in teaching, learning and assessment can be seen as a cyclical process incrementally building upon prior learning. Teachers should give pupils tasks in increasingly difficult contexts across all areas of learning with a progressively challenging range of information and concepts (GB.DfE 2022c).

3.2 Progression in science learning and outdoor learning.

To make real progress, primary school pupils need: clear development in all aspects of science learning; the interest and motivation to learn; the confidence to try, struggle and even fail; and the ability to learn from experience (Harlen *et al.* 2003). Careful planning is essential for teaching and learning across the curriculum and assessment should be complementary and aid the progression of the children (GB.DfE 2022c). In line with the constructivist approach to this study, children should have ownership of their learning and conceptual choices. Within an outdoor environment, they should also take an informed part in decision-making and take appropriate actions, which not only affect their own wellbeing but also that of others and their environment (O'Brian and Lomas 2016).

A view of progression in ideas and skills is needed in order to keep in mind the long-term aims of working towards the 'big ideas' from Harlen *et al.* (2010) and developing enquiry skills, when planning learning activities. The nature of progression within outdoor learning demonstrates a gap in current research. Rickinson *et al*. (2004) raised the point that, despite claims of wide-reaching benefits of outdoor learning, the emphasis when using the grounds lies elsewhere "rather than improving opportunities to learn in the environment, the lack of appropriate aims may well lead to missed opportunities for student learning" (p.53). There is a need to map out the route from small to big ideas and from simple to complex skills that can be used in the outdoors with a view to them being widely applied in a range of contexts (Harlen 2018).

In primary schools, indicators of progression (Harlen and Qualter 2014) are detailed in terms of enquiry skills and are highlighted in the CIEC (2021) document.

Figure 3: This shows the indicators of progression for Upper Key Stage two (CIEC 2021, p11). [3]

The indicators of progression (Figure 3) are used for teacher assessment and are seen as valuable tools for the purpose of criterion referencing as they relate to the 'Working Significancy' component in the science National Curriculum (GB.DfE 2013). The criteria lack relevance in the context of outdoor learning because it focuses more on procedural skills such as use of apparatus and enquiry techniques as opposed to thinking scientifically. Project Calibrate (Erduran *et al.* 2020) acknowledges the need for a closely aligned explanatory framework (Bransford, Brown and Cocking 1999) in science education which relates to thinking scientifically. It moves beyond the empirical evidence and procedures of data collection and interpretation to the reasoning relating to the validity and justification of evidence collection. The project aims to explore how practical science is related to higher order thinking skills such as argumentation (Osborne *et al.* 2016) and communication such as evaluating evidence, justification of claims and minds on approaches including critical analysis and evaluation (Russell and

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McGuigan 2018). It also highlights the importance of an holistic interpretation of aspects of science education, where all available evidence is compared and learner proficiency is evaluated against set criteria (Jonsson, Balan and Hartell 2021), whilst acknowledging the complexities and varieties within the learning.

Black *et al*. (2011) explored the value in teachers using more holistic judgments in their assessment for learning. It was found that teachers could learn to use more holistic judgements rather than rely on a prescriptive tick list. Where more prescriptive tick lists were available, a 'tick-box culture' (Mansell *et al.* 2009) was often created. In agreement with this is the concern related to 'criteria compliance' where Torrance (2005) noted that the goal becomes surface level ticking or highlighting of a large number of criteria rather than in-depth learning, leading to 'assessment as learning' with overly detailed objectives. Ward and Roden (2016) acknowledged there is a narrow focus on learning outcomes and standards rather than discovering the depth and breadth of children's understanding. This was supported by Davis (1998), James *et al.* (2007) and Swaffield (2011) who commented on the fine balance in the collection of the evidence and the importance of focusing on the learning process rather than performance outcomes. Working with children outside of the classroom may require a cultural shift for teachers in terms of expectations and assessments which are likely to be holistic, non-linear, informal and tacit (Ofsted 2019c).

Teacher assessment, which relies upon teachers' professional judgement of pupil attainment and progress based on evidence gathered through everyday learning (Wiliam and Black 1996), is important because it provides a more holistic judgement about children's learning. Sahlberg (2015, p.123) cites four main reasons why Finnish education relies on teacher assessment rather than external testing. This embedded approach is important when assessing in the outdoors due to the similarities in approach including the focus on the individual, improvement in learning over time, holistic diversity as well as valuing academic and social elements in internal reporting.

3.3 The use of Bloom's taxonomy (Bloom *et al.* 1956) to support assessment

The use of Bloom's taxonomy (Bloom *et al*. 1956) can be used to make holistic judgements to support teacher assessment. Within this theory, the coding of general processes within the cognitive domain move from simple to complex, including knowledge, comprehension, application, analysis, synthesis and evaluation. Cognitive performance is analysed through the categorisation of thinking skills ranging from recalling information to evaluation, thus highlighting the children's capabilities, critical thinking skills and providing appropriate challenge within the learning.

Their framework has influenced marking schemes and assessment objectives and is still referred to in teaching today. It has been used in schools to support planning and pedagogical choices (Gershon 2018) and to support questioning (Lord and Baviskar 2007; Askew 2015). It provides a common language to support learning objectives and curriculum design (Adams 2015). It has been used to support the provision of inclusivity (Sobel and Alston 2021) and create challenge in lessons that are differentiated appropriately. It has led to the development of mastery (Krathwohl 2002; EEF 2015; EEF 2019a) which underpins much of the current curriculum and work of the regional primary hubs (NCETM 2022).

Later revisions (Anderson *et al*. 2001) have questioned the hierarchical nature of the criteria and suggested that the processes are interlinked rather than being separate independent elements. Deleuze and Guattari's (1988) ideas challenge the structure of Bloom's taxonomy (Bloom *et al*. 1956) through their acknowledgment of the complexity and dynamic nature of learning; recognising that higher order thinking skills, such as synthesis and evaluation, require interconnectedness and sophistication. However, applying a constructivist lens, children are seen to make connections with and build on prior learning to make progress and Bloom's taxonomy (Bloom *et al*. 1956) helps learners to see what they can improve to be successful. It enables them to better understand their future learning.

Within this thesis, Bloom's taxonomy (Bloom *et al*. 1956) is used as a building block for understanding the learning. The principles provide a foundation for the science learning which focus on cognitive development in line with constructivism theory (Hayes 2005). It can also be linked to cognitive acceleration (Adey and Serret 2010) which has been defined as "the process of accelerating students' 'natural' development process through different stages of thinking ability, towards… abstract, logical and multivariate thinking" (Adey 1999 p7). It can be used flexibly rather than relying on set stages of development such as Piaget (1978) and can be used to provide a framework for successful learning in the outdoors, which has not previously been available due to its intangible nature.

The science associated with outdoor learning

4.1 The connection between science learning and outdoor learning.

The connection between science learning and outdoor learning provides the opportunity for children to develop enthusiasm for science learning, increase ownership and responsibility, as well as patience and self-esteem. It has also been found that British children are becoming disconnected from nature and as a result are struggling to identify common wildlife and plants for example of the 1000 children surveyed 83% of the children couldn't identify a bumble bee and 51% couldn't identify a nettle (McCarthy 2019). This emphasised the lack of experience in the outdoors (Patrick and Tunnicliffe 2011).

An outdoor approach to science provides the opportunity for children to experience adventure and a sense of wonder (Knight 2011) through 'flow' and 'flow learning'. 'Flow' (Csikszentmihalyi 1990) is defined as total immersion where the learner has control over actions in order to organise consciousness. It involves feeling 'at one' with nature. 'Flow learning' (Cornell 1989) is a process that empowers the learners through direct experiences with nature. Outdoor learning involves awakening enthusiasm, focusing attention, offering direct experience and sharing inspiration. In developing a sense of place, outdoor learning can provide children with the time and space to slow down and prioritise experiential and mindful experiences (Leather and Thorsteinsson 2021). These immersive opportunities, combined with the development of questioning and observation skills, engender deeper engagement with the natural world through sensory experiences. The connection also provides opportunities to link with communities of learners such as the Wildlife Trust, the Woodland Trust and wider conservation groups. Despite the argument that too much stimulus and distractions can be detrimental to learning (Cutting and Kelly 2015; Nel, Joubert and Hartell 2017), research has valued approaches that inspire a love of the natural world (Chawla and Cushing 2007; Capaldi, Dopko and Zalenski 2014; Pritchard *et al.* 2020) and biophilia (Wilson 1984) which creates opportunities for immersive and deep engagement. Ofsted (2008a) also found overwhelming evidence that outdoor learning not only contributes significantly to raising standards but also enhances the quality and depth of learning.

4.2 Learning using the outdoors

Outdoor science learning has typically been found to promote interconnected and contextualised learning (Lock and Glackin 2009; Dillon *et al*. 2005). Through exploration and investigation children make sense of themselves via sensory, first-hand experiences. In doing so they are making connections and setting out memory pathways and understanding. Strong memories tend to be linked with a sensual experience and this can be explored through the richness of experiences available outside and applied within the context of science. It is the totality of the experience, the purpose and immersion that enables them to make their own sense of the world and lead their own learning (Millar and Osborne 1998). Immersive and memorable experiences have positive cognitive and affective impacts on the learning (Nundy 1999; Rickinson *et al.* 2004). Research carried out by Dillon *et al.* (2005), with a focus on particular cognitive developments, went on to acknowledge that other domains, particularly learning about oneself and learning about working with others, also emerged, highlighting the value of freedom and quality of the experience when learning in the outdoors. This aligns with the focus of 'learning' from the PLaTO-Net ontology model (Lee *et al.* 2022) which makes connections between activities that are performed outdoors along with the purposes and outcomes that can be achieved.

When the learning is taken outdoors, it provides the concrete experiences in real-life situations that are relevant to this thesis, thus showing how experiential learning is relevant to outdoor learning. Within experiential learning, Dewey (1922) suggested that children create understanding through making sense of the world around them. He focused on understanding the depth of the experiences and highlighted the importance of the transaction between the children and their environment.

Examples of theoretical underpinning of current outdoor research include Isaacs (1933) who valued curiosity and Donaldson (1978) who valued embedded thinking. Both saw the potential for science learning in outdoor contexts. Isaacs (1933) used outdoor space to develop exploration and enquiry. Her aim was to stimulate curiosity rather than teach a curriculum. Her work was based on Froebel's (1887) learning-through-doing approach. She was also influenced by Dewey's (1938) focus on supporting children's interests and developing curiosity through the development of language to promote thinking. Donaldson's (1978) theory involved children making 'human sense' of a situation. 'Embedded' and 'disembedded' thinking was central to her theory. She believed, thinking that is embedded in a familiar context, such as the outdoors, makes 'human sense' and so is more easily understood by children as a result of their ability to understand through reasoning. This theory suggests that abstract concepts and disembedded thinking fails to make sense to a child; whilst learning that is embedded in an outdoor context and is facilitated in a child-led way, following the child's own curiosity, supports the focus of this research.

Following other studies such as Glackin (2013), Hoath (2015) and McDowell (2018) this research focuses on the effectiveness of outdoor science learning. They acknowledge the benefits of taking the learning outdoors and all three studies consider the role of the adult in facilitating outdoor science learning. They consider impacting factors on learning such as how teachers' beliefs inform their efficacy, management of transitions to support border-crossing between the indoors and outdoors and also the use of digital technologies whist considering the balance between discovery learning and the degree of scaffolding. I look at outdoor science learning from the stance of trainee teachers and explore the learning through the application of assessment in order to effectively support outdoor learning. McDowell (2018) is most closely aligned to this research due to the focus on experiential learning, although it doesn't look specifically at enquiry skills.

4.3 Primary science and the outdoor provision in schools

Philosophically, much of primary science can be abstract in nature, such as learning about photosynthesis, forces and space, therefore, when it is taught in classrooms it can automatically be out of context. In both primary and secondary schools, science is generally taught inside the classroom and within secondary schools ecology fieldwork tends to be organised one-off visits (Glackin 2016). However, Bianchi and Feasey (2011) argue that science should not be regarded as an indoor subject as the immediate classroom environment has limitations, since it offers a sterile version of science. To develop independence with enquiry skills; children need to be offered a meaningful environment where these can be fostered, enabling them to make connections to pre-existing knowledge (Bell *et al*. 2009; Harlen and Qualter 2014; Cutting and Kelly 2015). Unlike some subjects within the curriculum, some argue that science lends itself to the outdoors (Sharp *et al*. 2017).

Working in the outdoors provides opportunities to learn from real-life and real-world experiences. NAEE (2012) highlight the importance of contextualised learning and real-world meaning in order to make learning memorable and inspirational. In the review of the curriculum, Alexander *et al.* (2009) suggested that schools should engage children with real-life issues and the curriculum should not be limited to inward looking agendas. They welcomed a broad curriculum that engaged with macro-problems such as global warning, sustainability and pollution related to the real-world (Alexander *et al.* 2009). The National Curriculum (GB.DfE 2013) contains many statements suggesting that the use of the outdoors is key to its effective delivery. Examples can be drawn from across the range of subjects throughout Key Stages one to four (5-16). The introduction to the National Curriculum for Science states "teachers will wish to use different contexts to maximise their pupils' engagement with and motivation to study science" (GB.DfE 2013, p.145) and identifies specifically where children should be taken into the outdoor setting to study areas such as habitats and living things. Looking beyond children's relationship with nature, outdoor science also provides learning opportunities within physics and chemistry (Hornby 2016). Examples include learning about Newton's Law of Inertia, centripetal force, Boyles Law and aerodynamics in relation to physics (Aspinall 2016) and understanding ultraviolet radiation by using natural sunscreen derived from plants linked to chemistry (Engl and Risch 2016). This emphasises the scope of science learning that can be utilised within the outdoors.

Outdoor learning is highly relevant to the Early Years (GB.DfE 2017; GB.DfE 2021b), IBL (Inquiry-Based Learning) (Pedaste 2015), UNSECO (United Nations Educational, Scientific and Cultural Organisation) (UNESCO 2015) and through approaches such as the Forest School initiative (Knight 2013; Constable 2017). The government (GB.DfES 2006) and international approaches (GoUSA 2015) have demonstrated an interest in promoting the provision of outdoor learning, yet the teaching of science in the outdoors remains low (Ofsted 2008a; Ofsted 2011). To be able to embrace outdoor education, teachers need to have an understanding of the impact that engagement has on social and academic achievement as well as confidence.

The Forest School principles clearly state that it is not an outdoor science lesson (Knight 2011). Yet, practitioners acknowledge the special relationship that it has with science and the opportunities for child-led enquiry that couldn't be planned for (Hayward 2018), where the children's own investigations, observations, explanations and descriptions of their explorations provide them with confidence. Teaching primary science in the outdoors is also seen to be more reactive, in-the-moment, rather than through planned opportunities for learning which are associated with the indoors (Warden 2011; Hoath and Spring 2018). This follows Early Years practice (GB.DfE 2021b; Early Education 2021) but can be seen as alien for some Key Stage two teachers who are expected to teach to meet the end of Key Stage two expectations as a priority through planned opportunities for learning. In Norway, even with the high priority placed on outdoor learning, researchers reported that children's use of natural areas is becoming more directed and time-controlled by adults rather than self-initiated (Skar, Gundersen and O'Brien 2016). A report by Skar and Krogh (2009) found that a more structured reality offered controlled and organised nature-based experiences and a more distanced relationship with nature. Less intuitive embodied experiences in nature can create a sense of alienation from nature. This suggests a disconnect with exploration within an experiential approach to learning.

Despite 79 percent of teachers who were surveyed saying that outdoor learning had a positive impact on their teaching practice (Natural England 2016), outdoor learning is often not a priority in schools beyond the Early Years due to issues such as teacher confidence (Natural England 2011), funding, attitudes, available space and external forces such as weather (Waite 2009). Ofsted (2008a) also suggested that health and safety, time, behaviour and workload pressures were frequently seen as barriers to outdoor learning in schools. Despite the increasing popularity of Forest School training (Bryant 2021) and wilderness schooling (Quibell, Charlton and Law 2017), outdoor learning should go beyond the institutionalisation and commodification of outdoor practices (Leather 2018) to enable all children to have the opportunity to experience outdoor learning in schools (O'Brien and Murray 2006). Early experiences are crucial in developing familiarity with and knowledge of natural environments through sustained-regular engagement with the outdoors (Leather 2018). Dillon *et al.* (2005) and Williams and Scott (2019) acknowledged the realities of using the outdoors as an educational setting, such as issues with curriculum integration and varied practice. In relation to this, only eight percent of children (aged 6-15) in England were found to have visited the natural environment with their schools in an average month during 2013-2015 (Natural England 2017). This lack of sustained-regular engagement with the outdoors provides limited opportunities for teachers to build their confidence, understand what progression looks like and demonstrate impact on learning within this context.

Many publications for example, Beames, Higgins and Nicol, (2012); Waite (2011) and Bianchi and Feasey (2011) support the view that working outside the classroom offers many positive benefits for children and their learning. Foulds and Rowe (1996) showed that when science subject knowledge teaching and enquiry skills are integrated into the learning activities of children, then the children's understanding can improve. This is reinforced by Waite and Rea (2007) who suggested that incorporating the learning of science through the outdoors has resulted in the driving up of standards through a re-awakening of joy in learning.

4.4 Outdoor policy

The last few years have seen working outside the classroom appearing on the political agenda with some consistency and from a variety of educational bodies (GB.DfES 2006; Ofsted 2008a; CSFC 2010); yet the emphasis on teaching and learning in the outdoors has not necessarily being translated into practice. Children now spend more time in classrooms engaged in structured learning activities; although evidence suggests that children learn more effectively when engaged in experiential learning, such as through learning outdoors (van Oers 2003). The decline in outdoor learning as part of the school day was believed to be partially due to changes in educational policy, which have increased focus on attainment and pressure to achieve National Standards (Powell *et al.* 2009).

The government policy for learning outside the classroom in England has not been updated since the Learning Outside the Classroom Manifesto (GB.DfES 2006) which set out a "vision to enable every young person to experience the world beyond the classroom as an essential part of their learning and personal development" (GB.DfES 2006). Learning outside the classroom was withdrawn in 2016 but was seen as an example of good practice at the time (Beames, Higgins and Nicol 2012). The government's report (CSFC 2010) urged the Quality and Curriculum Development Agency (QCDA) to include learning outside the classroom within all curricula and schemes of work. They also suggested Ofsted should comment on the extent and quality of such learning through their inspection regime however the 2015 and 2019 frameworks for School Inspection (Ofsted 2015; Ofsted 2019e) make no specific mention of teaching and learning in a setting other than the classroom. The 2019 Early Years Inspection Handbook (Ofsted 2019a) included outdoor learning in the criteria for good and outstanding practice in relation to personal development which acknowledges the current increasing prioritisation of outdoor learning.

4.5 Social benefits of outdoor learning

Child obesity and mental health in the UK have been impacted by changing in lifestyles, which involve being less physically active (WHO 2016). Low engagement with the outdoors was highlighted in research which stated that on average children spend about an hour a day outside, compared to the three hours of their grandparents' generation (Singh 2014). Of the 7,000 children surveyed, nine in ten had never played conkers, built a raft or used a map or compass. Another survey suggested that children spent the equivalent of one day a week engaged in sofa-bound activities compared to just two-and-a-half hours outside (Adams 2012). This situation has been magnified more recently as a result of the global pandemic, where social inequalities have also been highlighted, with six in ten children reported to have spent less time outdoors since the start of the pandemic (Natural England 2021). This adds to the importance and need for outdoor learning in schools as it will also make a difference to the health and social needs of the next generation.

Moving beyond health, taking science learning outdoors offers opportunities for children to develop and deepen cognitive, affective, social and behavioural understandings and skills (Dillon *et al.* 2005; Rickinson *et al.* 2004). Focusing on the social elements, skill development can be supported in a collaborative environment with peers and teachers working together (Harlen and Qualter 2018). Open communication with extended periods of dialogue facilitate engagement and reflection when working outdoors (Perry 2001). High levels of involvement can be maintained through peer collaboration, high expectations and taking responsibility for managing personal risks. The ownership and physical familiarity helps children to be confident in their learning (Dillon *et al.* 2005; Carrier 2009; Moss 2012; Scott 2015).

The first-hand experiences of learning outside the classroom can help to make subjects more vivid and interesting for pupils and enhance their understanding (Dewey 1938).

It can also contribute significantly to pupils' personal, social and emotional development (Ofsted 2008a). Outdoor experiences that help to raise their self-esteem, give them confidence and increase motivation (CSFC 2010). Waite (2011, p.25) suggested that the greater "sense of well-being, freedom and enjoyment the children gain from being outdoors aids motivation ….and so benefit from the sense of being free which the outdoors can offer". Benefits such as physical (Pellegrini and Smith 1998) and emotional and social well-being (Perry 2001) were also claimed. These benefits are highly relevant to the teaching and learning using the outdoors. There has been an increasing urgency for society to recognise the needs of the child since the publication of the UN convention on the rights of the child (United Nations 1989) where article 13, 24 and 29 highlight the importance of:

- having access to information and having the freedom to express their thoughts and opinions;
- the right to an education on health and well-being so that children can stay healthy;
- the right to develop every child's personality, talents and abilities to the full including respect for the other people and the environment.

Children's experience of enjoyment in the outdoors is widely reported (Millward and Whey 1997; Waite and Rea 2007). There is evidence that enjoyment and autonomy of choice contribute to improved learning and the application of that learning. For example, Erk *et al*. (2003) found words stored in a positive emotional context were remembered better than those in neutral or negative contexts, so that what children wish to learn and take enjoyment from will result in learning being better retained than what they have no choice about. Some ambivalence still remains around whether enjoyment is really advocated as the route to desired improvement as can be seen by the priority of 'Excellence' over 'Enjoyment' (GB.DfES 2003) in government documents.

Wider benefits to learning outdoors have been found to provide opportunities for children to develop enthusiasm for learning, increase a sense of ownership and responsibility, learn patience and improve self-esteem (Lieberman and Hoody 1998), and shape important values about nature (Ratcliffe 2007). Through the use of real-world contexts, children are able to engage with science-related issues, with the ideas of science, as reflective citizens (OECD 2016) and they can develop their own real personal identity which will be needed when competing for jobs and becoming skilful members of society and citizens of the world according to the UN (2016) sustainable development goals.

Summary

5.1 Reflection on the literature

Science learning in the outdoors tends to focus upon social benefits, professional perceptions and confidence of teachers and children rather than scientific literacy (Waite 2011, Glackin 2016, Harris 2017). This leaves issues such as learning outcomes, the quality of learning and its impact on children under-discussed (Bianchi, Whittaker and Poole 2021). What has not been addressed in the literature is an understanding of the learning that is taking place which is central to understanding how teachers can most effectively support children's scientific learning in the outdoors.

There is a need to find evidence to support and justify the quality of science learning that is naturally occurring in the outdoors. This relies upon the learning being in context and the assessments informing the children's next steps (James 1998). Learning from experience is frequently determined by the quality of the experience, relevance, element of freedom and interconnected opportunities which can be seen as complementary or supplementary to the wider learning of the child. The context can be used to maximise engagement and motivation may indirectly improve standards and impact learning academically (Dillon *et al.* 2005). This has been proven through a range of initiatives and international approaches. Although this was problematic in an accountability culture, in terms of outcomes, it was deemed important to maximise contextualised learning to extend learning.

Methods and methodology

Paradigm

6:1 Research paradigm

The aim of this research is to ‘understand what constitutes effective outdoor science learning’ involving the construction of meaning and this is integral to the main research question asking, ‘how can trainee teachers most effectively support children’s learning in primary science using the outdoors?’. There is an understanding that personal realities contribute to developing shared meanings. This research places value on authentic child-initiated questions, independent thought and scientific behaviour. Lincoln and Guba (1985) suggest that meaning is associated with views, feelings, behaviour and conceptual understanding. This can be seen in the research questions which focus on thinking, attitudes, progress and challenges. These questions do not align with a positivist approach as they are not objective or measurable. Instead, they are more abstract because they are based on realities that involve perception and are mind-dependent (Coe *et al.* 2017). This refers to how the learning is interpreted by trainee teachers using an assessment matrix (section 8.1.2) and the meaning that is assigned to the learning by the trainee teachers.

In order to develop an understanding of the illusive and intangible quality of social phenomena which are apparent in the primary school context within this research, an interpretivist lens has been used to frame the methodological design. It aligns with this thesis because it focuses on authentic and unique learning opportunities (Denzin and Lincoln 2011) where the children are learning about science through hands-on, concrete, outdoor experiences in a child-led way. This highlights the importance of understanding “the subjective world of the human experience” (Cohen, Manion and Morrison 2011 p.17) in order to understand the individual nature of the children’s experiences that informed the learning. Whilst I am using an interpretivist lens to help to develop an understanding of the multifaceted ways that children’s learning is interpreted by trainee teachers in the outdoors, the analysis will be considered in relation to practice in order to contribute to pedagogical approaches that are research-informed.

Interpretivism involves the development of webs of meaning which are dynamic in nature (Lincoln and Guba 1985). It seeks out subjective beliefs, where, in this thesis, meaning is co-created between the researcher and the trainees in an interactive and inseparable way (Lincoln and Guba 2016). It focuses on understanding, meaning and action as opposed to the more positivist approach which includes explanation, prediction and control (Carr and Kemmis 1986). Whilst acknowledging that there are an infinite number of different descriptions from different perspectives, interpretivism involves ascribing meaning to features of the learning. In relation to this research, an interpretivist stance allows me to generate an understanding of the ways that children learn science by putting the children's learning at its centre, acknowledging their reflections, whilst also capturing their unique actions and thinking (Roberts-Holmes 2011; Burton and Bartlett 2016).

My epistemological position, regarding the nature of knowledge, is allied to a constructivist perspective. This involves actively constructing meanings of the world (Giddens 1976) through cognitive (Piaget 1978; Lourenço 2016) and social activity (Vygotsky 1978; Schreiber and Valle 2013). In this research, the constructivist view provides a lens to help understand how learning has taken place. It acknowledges the complexities involved in developing an understanding of children's learning. The constructivist view is also based on the assumption that new meaning and understanding is constructed based on experiences (Hammersley 2008) and by integrating new information with prior knowledge (Cohen, Manion and Morrison 2018). Within this thesis, this view is used to help explain the way children learn science in the outdoor context, building on their prior learning and experiences.

This constructivist perspective was influenced by the work of Dewey (1938) whose learning theory of experience advocated experiential learning. It helped to explain the use of learning through *reflection on doing* (Dewey 1938; Kolb 1984). Situating the learning outdoors allows the children to reflect on their regular, first-hand experiences of science-in-action and construct their understanding in context. This research focuses on multiple realities which are context bound and interactive. Details which describe the learning culture, such as the children's actions and attitudes in the outdoors as well as their thinking processes from the perspective of both the researcher and the trainee teachers as insiders (Pollard 2014), are used to construct an overall view of the learning (Guba and Lincoln 1982). Using these rich or 'thick descriptions' (Geertz 1973) enables an articulation of the social actions which include both the physical behaviours and an interpretation of the context.

Although interpretivist paradigms have been critiqued as too subjective, with the risk of misinterpretation (Burton and Bartlett 2016), this approach made it possible to explore scientific learning in the outdoor context whilst maintaining the credibility and integrity of the learning. It provided the opportunity to understand the uniqueness and complexity of the ways in which children learn, including observable aspects associated with learning in-the-moment (Pring 2015). Accepting the messiness of researching the social world in order to understand learning, the additional step of triangulation (Denzin 1970) was used to improve validity. This was achieved through the use of multiple perspectives from the participants, which included the children and the trainee teachers, as well as the researcher. The validity of the interpretations was increased by the number of participants involved, as well as the co-construction of meaning between the researcher and trainees. The goal was not to provide *accurate* representations of the educational phenomena but instead to reflect the more *abstract* nature of individual and social circumstances. This social approach was dynamic and required researcher transparency (Clough and Nutbrown, 2012).

6.2 My positionality within the research

My position is shaped by my lived experiences and own values (Sandhu 2017). Having previously been a teacher and acted as a facilitator of the learning, my experiences of applying constructivism within my practice, scaffolding the children's learning and assessing learning through formative and summative assessment (Wiliam and Black 1996) will affect my assumptions and interpretations within this research.

The social world is said to be better understood from the stance of individuals who are part of the ongoing action being explored rather than from the stance of an objective observer (Cohen, Manion and Morrison 2007). I was very much part of the *ongoing action*; firstly, as a university lecturer undertaking this research and secondly, having been a primary school teacher with an understanding of learning expectations and children's needs. My positionality allowed me to appreciate situations through the eyes of the participants; in other words, those of the children and the trainee teachers, and not simply through the eyes of the researcher (Cohen, Manion and Morrison 2011). It enabled me to share the trainees' stance and understand their interpretations of the learning, giving meaning to the collective experiences (Dervin 1998) through sense-making. This allowed me to take a subjective approach when dealing with their direct experience of working with the children in the outdoor context.

The nature of this research required me, as the researcher, to have a continually shifting position in relation to insider and outsider research (Merton 1972). This was demonstrated through the application of Bank's (1998) practice-based researcher model which focused on insider and outsider positioning. The model represents differences in researchers' knowledge and values, based on the communities they are working with (Kerstetter 2012). This included the relationship to the research participants, which influences how the researcher is positioned in that space (Smith 1999). In this research, I had two roles, an indigenous insider and an external insider.

For instance, whilst in university, I was an *indigenous insider,* guiding the trainees in their role of facilitators of the research. As I work as a lecturer in the institution, I ascribe to the values and practices of the university, for instance embracing its ambitions and approaches (NTU 2022). It was also important for me to adopt a wider perspective beyond the university, through the field of research, in order to be aware of current influences and more diverse possibilities within primary science and outdoor learning. This enabled me to move beyond the instruction of trainees, such as focusing on metacognition, enabling them to develop their own professional effectiveness.

Yet, having taught in primary schools before becoming a university lecturer in schools, I also took the position of an *external insider* when the trainees collected and interpreted the data. Understanding the pedagogical requirements, I was well placed to lead the academic focus and being removed provided me with less subjectivity within the analysis; I took a privileged position by sitting back and having an overview. I listened to the responses from the trainee teachers and realised the importance of hearing their 'voice' (Mauthner and Birch 2002). This was necessary to value their perspectives, providing a broader and more holistic knowledge about the children through the detail in their interpretation of the children's learning (Greig, Taylor and MacKay 2007).

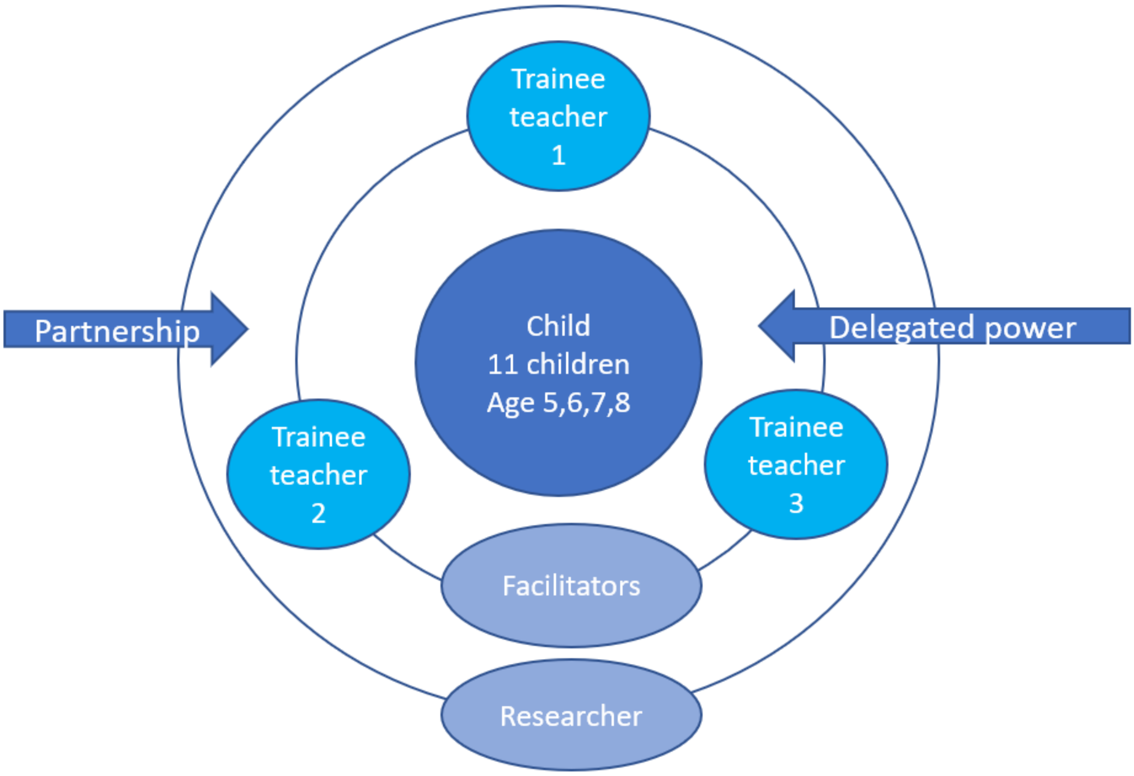
Whilst appreciating the trainees' interpretations of the learning, as a researcher, my role also involved being an interpreter in the field and making sense of the learning

(Dervin 1998). As an *insider* and as a former teacher, I had an appreciation for how the cases were able to function within practice, for example taking into consideration the curriculum expectations. This supported the trust worthiness and credibility of the approach. I was aware of the ethical implications for instance those associated with biases such as deciding what was important to highlight or interconnect but valued my own insights and deep understanding of the context (Anderson and Shattuck 2012). In terms of my personal researcher identity, I interrogated my own values and logics as well as those of the participants. I needed both *critical reflexivity* to have an awareness of how I think and *dialectical reflexivity* to have an awareness of wider influences on how I think (McNiff and Whitehead 2009). The deconstruction of my usual way of thinking (Derrida 1997) was achieved through an openness to alternatives and a questioning approach. This enabled me to see things from a different perspective, in order to understand the children's and the trainees' perceptions.

6.3 Role of the trainee

The trainee teachers were working in their fourth and final block placement school, collecting the primary data as *indigenous insiders* and acting as facilitators of the research (O'Mara and Gutierrez 2010) (Figure 4). They were science specialists who were well positioned for this role because of their strong subject knowledge and passion for developing their expertise in school (Silverman 2006). The trainees' knowledge of the science curriculum meant that their expectations of the learning and knowledge of the prior-learning were robust. In addition, having already established trainee-child relationships, they were best placed to understand the children and their learning in an holistic way, whilst also conducting the data collection in line with the children's usual learning experiences, thus putting the children at ease.

Rather than co-researchers (Hartley and Benington 2000), the trainee teachers were 'facilitators' of the research in line with Arnstein's (1969) topology of participation, which describes the power and decision-making involved in their role within the research. Based on the eight *rungs* of participation on the continuum of participatory power, the trainees worked in *partnership* (rung 6) with myself as the researcher, with shared decision-making responsibilities. When they were in their placement schools, facilitating and being accountable for the data collection, they were *delegated power* (rung 7) where a higher degree of participant control, management and decision-making authority were given to them. The trainee teachers had responsibility for the learning and the researcher had the additional responsibility for the overarching research paradigm.



<u>Figure 4</u>: This shows the methodological approach for the research with the child at the centre. (The concentric rings represent an increasing level of responsibility and degree of participant control).

As science specialists, the trainee teachers have been developing the skills to support children's substantive and disciplinary knowledge. However, working with children outside of the classroom may have required a cultural shift for them in terms of their expectations and pedagogical approaches. Despite the narrow focus on learning outcomes and a testing culture that has been evident within primary education for a number of years; the role of these trainee teachers was one that favoured intervention over instructional models (Muijs and Reynolds 2018) and put the child at the centre of their approach.

In order to empower the trainees in their role as facilitators, it was necessary to support them to critique ideology, develop reflective practice and link practice with research. It was necessary for them to fully engage in critical reflection when evaluating the learning in which they either validated or challenged my interpretations by offering alternative perspectives (Opie 2004). The trainees were given the autonomy to identify learning moments independently and their reflections were supported at regular intervals through online meetings. The children's learning examples were also used to triangulate the trainee reflections and monitor the consistency of approach, such as reviewing the ease of using recording methods in context, overcoming barriers and making successful adaptations. Reflecting on the learning not only enabled the trainees to *make sense of the world* offering explanation, clarification and demystification of the learning (Beck 1979) but also enabled them to examine situations through the eyes of the children (Cohen, Manion and Morrison 2011).

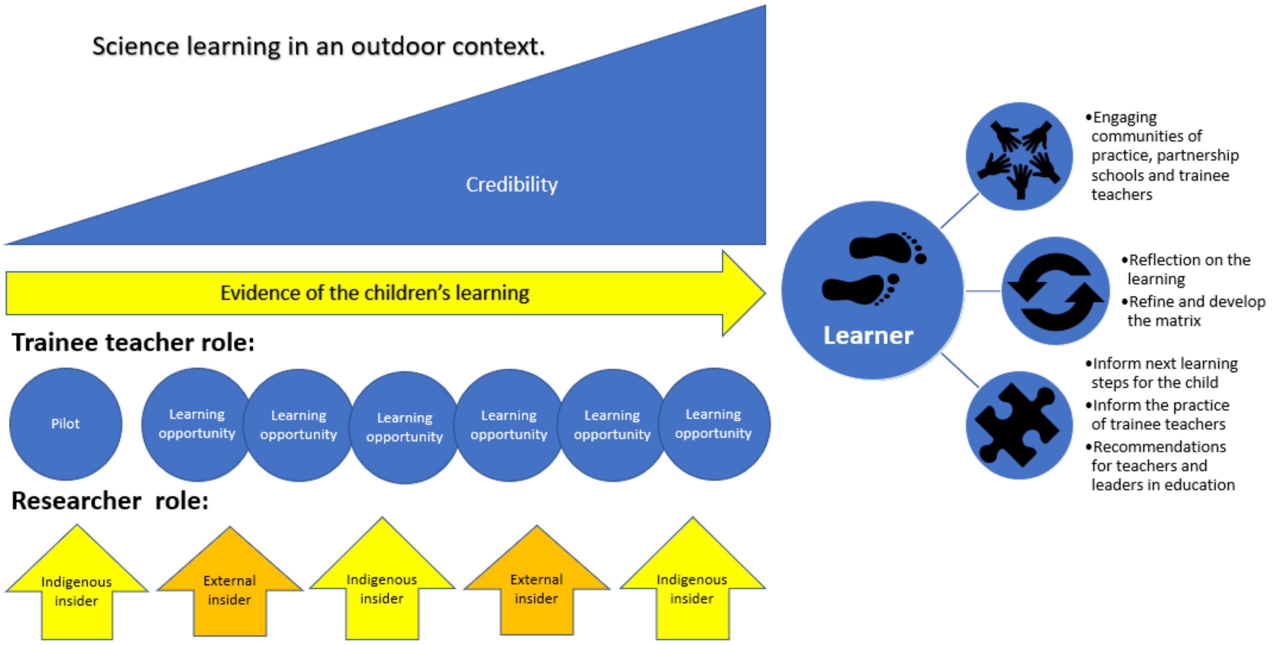


Figure 5: **This shows the connection between the role of the trainees and the researcher over the research period and how this impacted on the learner.**

Figure 5 demonstrates the impact that the role of the trainee teacher had on the learner. They facilitated the research through collecting data about the learning over a series of linked learning opportunities and setting challenging targets for the children's next learning steps. Their role also included regular review and reflection on the learning. The role of the researcher changed at certain points in time and the figure shows the connection between the trainees and the researcher including the guided reflection on and interpretation of the learning. The credibility of the research increased as the evidence of learning was collected. The findings informed the learners progress and the researcher analysis and recommendations for teachers and leaders in education.

The actions the trainees undertook:

1. Learnt how to use the research tools
2. Followed the ethical protocol in preparation for the data collection
3. Collected the data in their placement school using the research tools
4. Completed regular reflections on the learning
5. Interpreted the data that was collected with researcher support to identify next steps for learners in interview
6. Provided evidence for researcher analysis

Methodology

7.1 Methodological outline

This research followed a qualitative research approach. In terms of 'fitness for purpose', research in schools does not consistently match with quantitative methods and so qualitative data was collected in order to provide a consistent approach that could be applied to all primary schools. Qualitative research can delve deep into what the findings show, and triangulation of the data ensures it is authentic and meaningful (Denzin 1970). It enables the social world to be studied in its natural state and recognises the uniqueness and fluidity of individuals and events (Cohen, Manion and Morrison 2018). It provides opportunities to capture multiple *interpretations of* and *perspectives on* events and situations. It is affected by the context and the situational changes that evolve over time, demonstrating its complexity.

However, qualitative approaches within education have been criticised for not being sufficiently rigorous (Mercer *et al*. 2001; Hammersley 2008). It has been recognised that there are a variety of interpretations of the learning (Silverman, 2016), leading to concerns about the validity of the research, which stem from its perceived trustworthiness, consistency and neutrality (Lincoln and Guba 1985). Whilst learning in education can be seen as messy and full of contradictions, complexity and disjunctions, it is also celebrated for its richness and connectedness (Cohen, Manion and Morrison

2007). The unique, multi-layered nature of learning also means that it is not exposed to the fragmentation process found in much quantitative research. This was of particular relevance to the uniqueness of authentic outdoor learning and the diversity of learning involved in an experiential approach to practical science.

7.2 Refined research approach

In developing the research design for my thesis, I considered the appropriateness of design-based research, action research and case study methodologies. These research approaches aligned with my focus on learning in the outdoors and linked with constructive elements from practice (O'Gorman and MacIntosh 2015). Each can be situated in a real educational context (Anderson and Shattuck 2012) and reflection is an integral component of these approaches. In addition, all seek to demonstrate an impact on practice.

However, this thesis does not use a design-based research approach, which typically uses mixed methods and multiple iterations within a transformative agenda. The focus on the evolution of design principles differentiates design-based research from both action research and case study approaches. Design-based research moves beyond observing to systematically engineering the contexts to allow evidence-based claims to be generated about learning (Barab and Squire 2004; Messick 1992). Whilst my research involved a form of intervention, the data collection was focused on the learning as opposed to the design of a pedagogical tool. Constructivism, which is the lens used to understand learning within this research, does not link well to the instructional organisation that is required within design-based research and so it was discounted as a method.

Action research was also discounted as a research approach. It differs from case study research in that it is transformative, as it relies on criticality and reflective cycles when conducting the research. Researchers using an action research approach, investigate and evaluate their work with a focus on improving their own practice and the practice of others (McNiff and Whitehead 2009). Although the use of research cycles is not the intention of my methodological approach, a focus on improving practice was likely to emerge from the research findings.

Case studies were deemed to be the most appropriate research approach for this research because they observe the effects in real-world contexts with an in-depth understanding necessary to justify the case (Cohen, Manion and Morrison 2011; Yin 2018). Specifically, multiple-case studies strive to portray what it is like to be in a particular situation, to find the close-up reality, and to provide a thick description of participants' experiences (Geertz 1973). Reality is also discussed as going beyond the context and can be viewed as a reality of different perceptions and experiences in a more holistic way (Yin 2018). Yet, reality has an elusive and intangible quality (Cohen, Manion and Morrison 2011) when looking at learning and social phenomena, which is apparent in the context of education. Multiple-case studies differ from standalone case studies by their content and approach being non-identical (Yin 2009). They provide a range of perspectives and accommodate issues arising from a number of contextual circumstances. These circumstances differ according to the participants' strengths and subject knowledge as well as the diversity of the school setting itself. Within this thesis, therefore, multiple-case studies were used in order to explore the patterns, commonalities and connections within outdoor science learning.

7.3 Multiple-case study approach

For the purpose of this thesis, the case study methodology was closely aligned with the definitions from Cohen, Manion and Morrison (2011) and Hayes (2019). I have defined case study as 'the means to understand a real-world situation, involving important contextual conditions'. Each of the three case studies focused on one trainee teacher and provided insight into the children's scientific learning through the unique school and outdoor contexts. This approach allowed examples of effective outdoor learning to be captured within defined parameters as part of the children's usual learning context and enabled a picture of their learning to be built over time to gauge their progress. This allowed trainees to effectively support children's learning in primary science.

Each case study involved (Figure 6a):

- One trainee, one school, three or four children and a series of four to five sessions, lasting between one and two hours.

Case study 1:
1 trainee [TR1], 1 school
4 children (age 5-6)
4 sessions: journey sticks, sound walk, insects, questioning

Case study 2:
1 trainee [TR2], 1 school
3 children (age 7-8)
5 sessions: minibeasts, bug hotel, exploration and identification, sensory hunt, sound investigation

Case study 3:
1 trainee [TR3], 1 school
4 children (age 7-8)
5 sessions: enquiry, questions, decomposition, bulbs & seeds, minibeasts

Figure 6a: This shows how the evidence of learning was collected within each of the three case studies.

The trainees collected the data over one Spring Term. A 'learning in action' booklet and observation was completed for each child, for each session. The trainees completed one 'thinking scientifically' matrix that was representative of their group of children at the end of the series of sessions. After the school experience and final degree submission, one interview per trainee occurred at the end of the summer term. Each case study comprised of evidence from three data collection methods.

The purpose of the multiple-case study approach was to produce 'Mode 2' knowledge (Gibbons *et al.* 1994), where emphasis was put on real-world contexts through generating knowledge in the context of the school and in the outdoor learning environment. The aim of the research was not to achieve reliable data but to explicate the ways in which children learn in the outdoors. The small-scale approach provided a snapshot of the children's experiential learning and focused on the rich quality of the data as opposed to the quantity of the examples (Fusch and Ness 2015). It was necessary to concentrate on smaller numbers of children during the learning, in order to improve the opportunity to collect multi-layered, intricate, detailed and nuanced evidence of learning.

There was also an appreciation of the limitations associated with using a multiple-case study approach. Shaughnessy, Zechmeister and Zechmeister (2012) suggested that case studies lack a high degree of control. This became apparent in the research, as the trainee teachers were facilitators of the research and were therefore involved in making decisions as *internal insiders*. However, following shared research principles minimised this. Each case study was non-identical. They varied as the participants were not of the same age, they had a different school situation and the content within each lesson was tailored to the children's needs and interests at that point in time. By observing in multiple situations and through the triangulation of the findings, cases were studied for what they revealed about the personalised learning, with the intention of better understanding the learning, as well as enabling more robust theory and gaining a fuller picture.

Whilst this research does not fit neatly into the categories of case study defined by Stake (1994) or Yin (2018), it does echo a 'collective' approach because it involves a body of data that focuses on the examples of science learning (Hamilton and Corbett-Whittier 2013). Within the multiple-case study approach, the trainees worked separately but followed the same methodology to gather the data about the learning, through a *collective* approach.

My thesis also draws upon a qualitative multiple-case study approach. It relies on the capacity of the researcher to interpret, translate and articulate the meaning (Hayes 2019). For instance, as an insider researcher, I was able to understand and articulate the meaning from the evidence of learning and trainees' observations and reflections. It was not about comparing trainees, schools or children but using evidence to exemplify new knowledge. A qualitative case study approach "facilitates exploration of a phenomenon within its context using a variety of data sources. It ensures that the issue is not explored through one lens, but rather a variety of lenses which allow for multiple facets of the phenomenon to be revealed and understood" (Baxter and Jack 2008, p544). When exploring science with children in an outdoor context, the evidence from data analysis and the variety of perspectives provided an opportunity to understand multiple aspects within the learning.

Lincoln and Guba (1985) and Atkins and Wallace (2012) highlight the complexity involved in a case study approach. In addition, Hayes (2019) pointed out the depth of analysis that is required for a single case. In relation to multiple-case studies, this was accentuated by within-case and cross-case analysis. The consistency in the research methods and the categories incorporated within the structure of the 'learning in action' booklet resulted in the data collection being *systematic*. It was also possible because each case included a series of four or five linked outdoor science lessons during the Spring Term and involved primary aged children from five to eight years old. The examples of learning 'in-the-moment' were more reliable than relying on practitioners' perceptions and beliefs (Ayotte-Beaudet *et al.* 2017; Glackin 2013; Dillon *et al.* 2005). Additionally, the examples were collected by science specialists in their fourth year of training, who had experience in using observation skills and had a strong subject knowledge background. Both of these approached to data collection supported the rigour of the approach. Although each case was unique, a multiple-case study approach enabled a common structure and expectations to be established thus making it possible to see the connections within the outdoor science learning that was occurring.

Methods

8.1 Introduction to the methods

In order to facilitate the outdoor learning and to capture data to help answer the research questions, I devised and developed two pedagogical tools: a 'learning in action' booklet and a 'thinking scientifically' matrix. The 'learning in action' booklet was a purposely designed pedagogical tool that was used to capture a variety of learning examples. It was a format onto which the children could write, draw and present photographs to represent their scientific thinking whilst outdoors and subsequently in the classroom. The trainees could also add detail to evidence the learning. It provided a basis to support the trainees in structuring their formative assessments. The 'thinking scientifically' matrix was designed to support the data collection and the assessment of learning by the trainee teachers. It also enabled me to both support the trainees with their assessment and analyse the learning that occurred across cases. It was a matrix in which success criteria demonstrated progression within the thinking scientifically learning outcomes. Trainees used the success criteria to plan for, measure and set expectations for the children's achievement. They completed one matrix that was representative of the group of children that they were working with at the end of the series of sessions.

The booklet and matrix pedagogical tools were piloted by the trainee teachers and refined as a result. This informed the main data collection and the subsequent data analysis. The key data collection methods included documentary analysis, observations and interviews. Details of the methods used can be seen in Figure 6b.

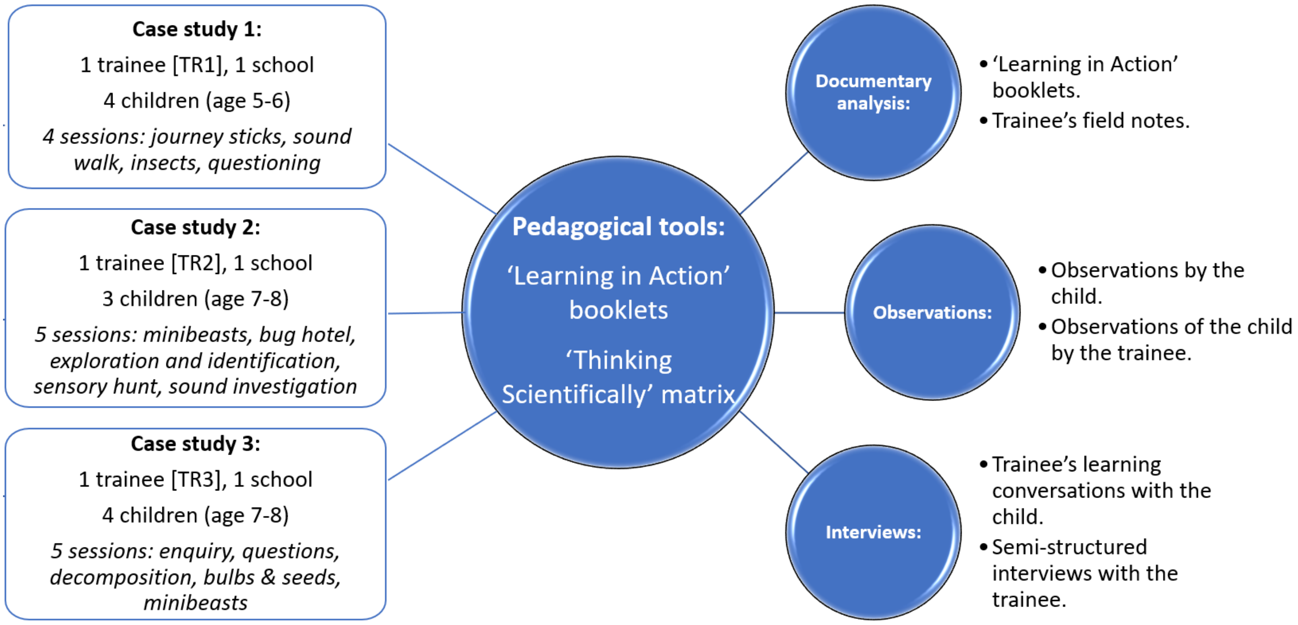


Figure 6b: This shows how the collection of evidence, which focused on the learning of the children from the three case studies, linked to the pedagogical tools and informed the data collection methods.

8.1.1 The 'learning in action' booklet

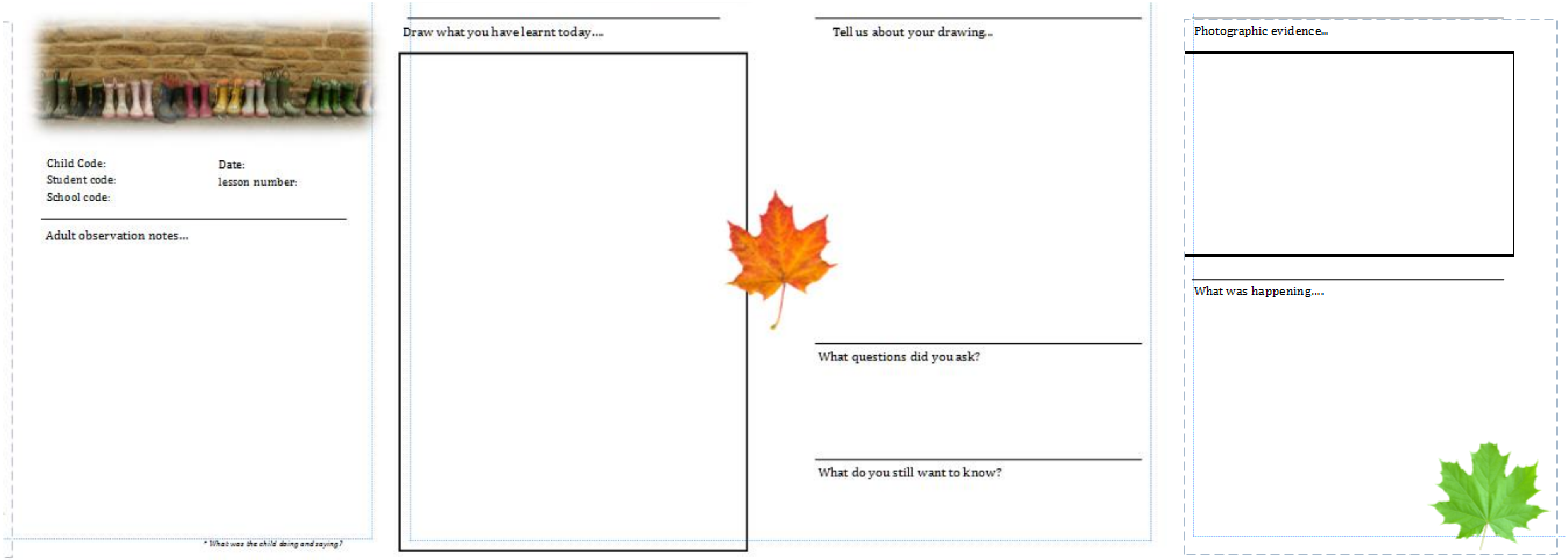
The 'learning in action' booklet (Figure 7) was the pedagogical tool that was used 'with' the children in line with the mosaic approach (Clark and Moss 2011). The mosaic approach is a framework for listening to young children while respecting them as experts in their own lives. The children play a direct role in constructing and discussing research material. The booklet enabled this by including areas for both the child's and trainee's observations. This evidence focused on 'critical incidents' through the recording of:

- children's drawings with their accompanying descriptions and reflections,
- children's questions in-the-moment and questions to consider in future,
- children's photographs of their learning,
- photographs of children's learning by the trainees,
- trainee observation notes.

I introduced the booklets to the trainees in university taught sessions. I shared a completed example as a model to set expectations (Appendix 1). The trainees then trialled the booklets with children from a local primary school in the pilot. The trainees subsequently took them into their placement schools where they were introduced to the children, using my model again as an example.

The booklets were used to capture aspects of the learning alongside the series of linked lessons that the trainees planned and provided evidence for documentary analysis within this research. The booklets were completed by the children while they were learning outside. The children recorded their observations, questions and reflections 'in action' and also captured further reflections of learning 'on action' after the learning. The trainees supported their use by asking questions, making links to prior learning and prompting memories and reflections. The children had responsibility for the booklets and their contents. They shared the ownership with the trainees who could scribe for the learner or add their own notes, additional detail and observations on the learning. This was recorded on page one of 'learning in action' booklet (Figure 7).

In terms of evidence collection, there was a need for consistency in capturing the learning and ensuring there was a shared understanding of the learning judgements. The tool was designed to provide the trainee with common expectations in data collection to support documentary analysis, irrespective of the learning opportunity. The expectations became accessible and enabled the trainees to evidence progression in learning. It was also important to have a format that enabled moderation and the structure made it easier to see gaps in learning, misconceptions and progressive strengths within the documentary analysis. The sections provided a structure for the recording, leading to the identification of the learning, appropriate support and development of criticality within the learning. The quality of the examples meant that they could be used to evaluate the learning and associated next steps. The sections also made it possible to notice missing information, points that did not align with scientific facts of evidence and examples of higher order thinking. The value of the thinking was realised through the quality of the questions, the purpose of the photographs, the articulation of the experiences in the descriptions and observations as well as the detail in the drawings.



Child Code:
Student code:
School code:

Date:
lesson number:

Adult observation notes…

* What was the child doing and saying?

Draw what you have learnt today….

Tell us about your drawing…

What questions did you ask?

What do you still want to know?

Photographic evidence…

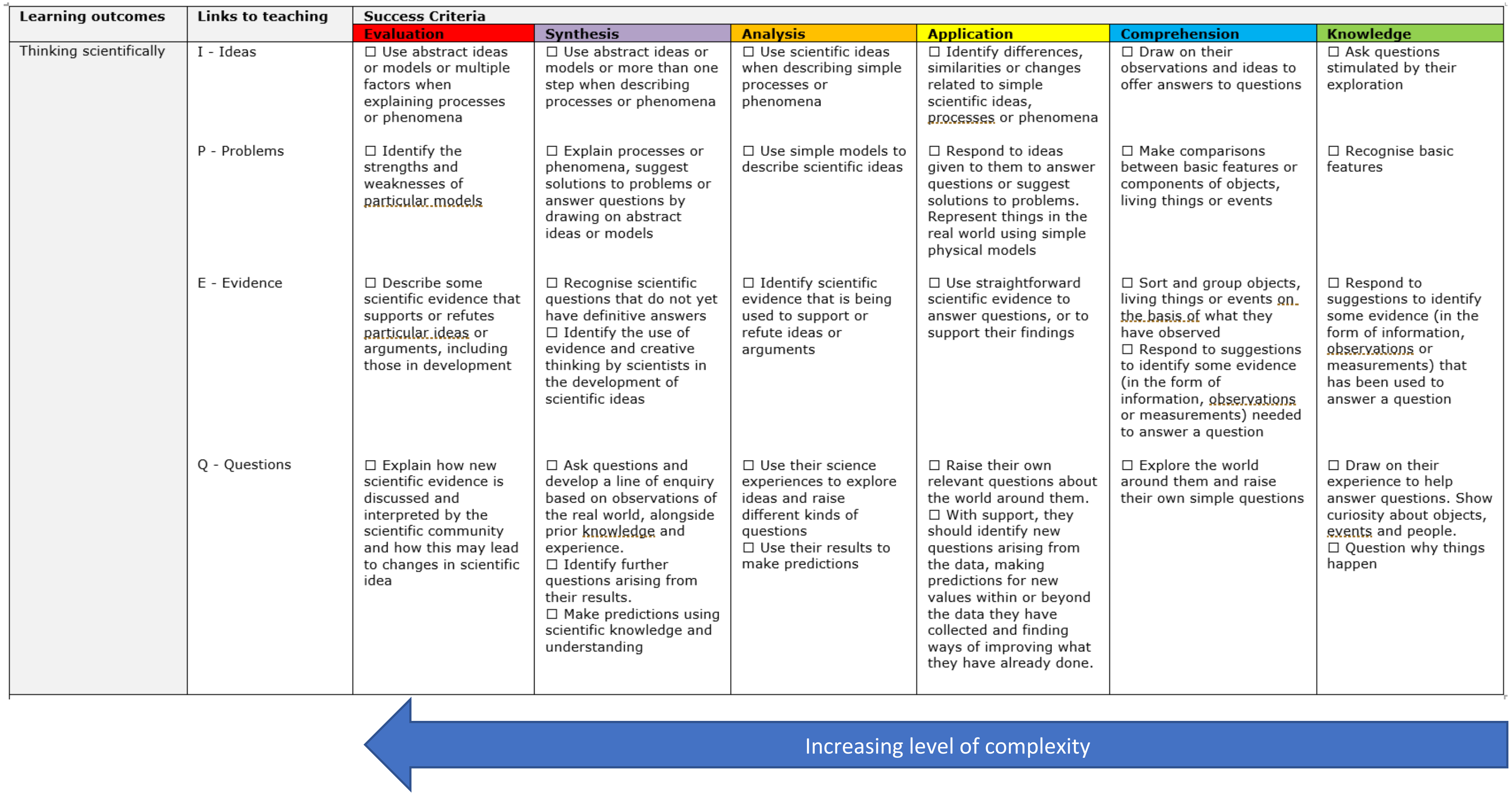
What was happening….

Figure 7: 'Learning in action' booklet.

8.1.2 The ‘thinking scientifically’ matrix

In contrast to the current assessment guidance (STA 2019) where progress in knowledge and understanding is measured over time in an in-class setting, this research focused on evidence of children’s learning through practical outdoor science. The children were assessed through the application of a spectrum of success criteria. These included specific small steps required to meet the learning outcome, with an understanding that their progress may not have been linear, continuous or comparable.

It was necessary for the trainees to understand the science learning outcomes that are relevant to the outdoors and effectively pitch their expectations, enabling children to be able to demonstrate their scientific literacy. The trainees’ understanding also allowed them to make consistent judgements about the practical science learning. As there was nothing in place to guide assessment judgments in relation to outdoor science practical learning, I developed a matrix that I called the ‘thinking scientifically’ matrix (Figure 8, Appendix 2) as a pedagogical tool.



Learning outcomes	Links to teaching	Success Criteria					
		Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
Thinking scientifically	I - Ideas	☐ Use abstract ideas or models or multiple factors when explaining processes or phenomena	☐ Use abstract ideas or models or more than one step when describing processes or phenomena	☐ Use scientific ideas when describing simple processes or phenomena	☐ Identify differences, similarities or changes related to simple scientific ideas, processes or phenomena	☐ Draw on their observations and ideas to offer answers to questions	☐ Ask questions stimulated by their exploration
	P - Problems	☐ Identify the strengths and weaknesses of particular models	☐ Explain processes or phenomena, suggest solutions to problems or answer questions by drawing on abstract ideas or models	☐ Use simple models to describe scientific ideas	☐ Respond to ideas given to them to answer questions or suggest solutions to problems. Represent things in the real world using simple physical models	☐ Make comparisons between basic features or components of objects, living things or events	☐ Recognise basic features
	E - Evidence	☐ Describe some scientific evidence that supports or refutes particular ideas or arguments, including those in development	☐ Recognise scientific questions that do not yet have definitive answers ☐ Identify the use of evidence and creative thinking by scientists in the development of scientific ideas	☐ Identify scientific evidence that is being used to support or refute ideas or arguments	☐ Use straightforward scientific evidence to answer questions, or to support their findings	☐ Sort and group objects, living things or events on the basis of what they have observed ☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) needed to answer a question	☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) that has been used to answer a question
	Q - Questions	☐ Explain how new scientific evidence is discussed and interpreted by the scientific community and how this may lead to changes in scientific idea	☐ Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience. ☐ Identify further questions arising from their results. ☐ Make predictions using scientific knowledge and understanding	☐ Use their science experiences to explore ideas and raise different kinds of questions ☐ Use their results to make predictions	☐ Raise their own relevant questions about the world around them. ☐ With support, they should identify new questions arising from the data, making predictions for new values within or beyond the data they have collected and finding ways of improving what they have already done.	☐ Explore the world around them and raise their own simple questions	☐ Draw on their experience to help answer questions. Show curiosity about objects, events and people. ☐ Question why things happen

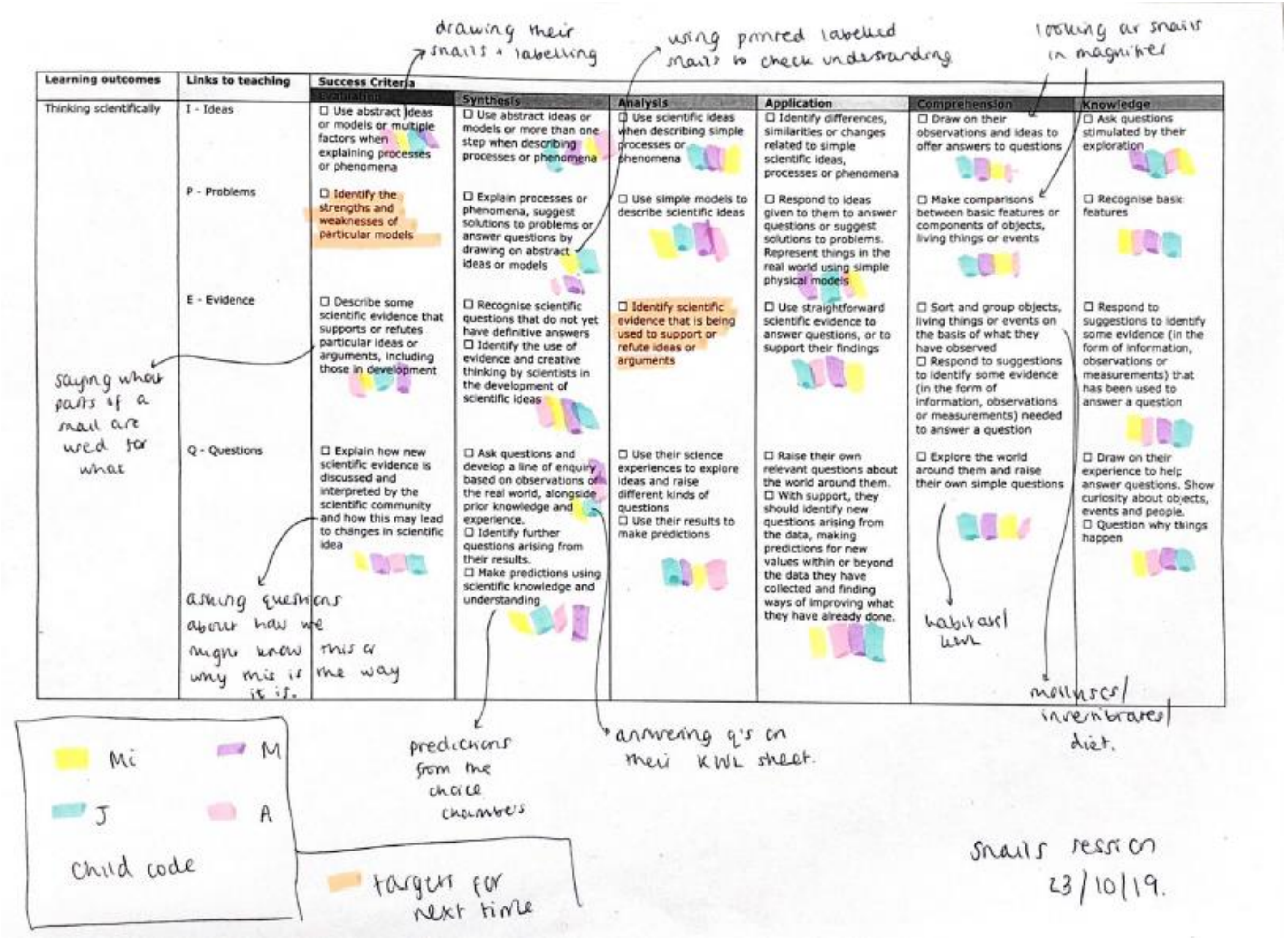
Figure 8: **'Thinking scientifically' matrix (Appendix 2)**

It originated from a fusion of ideas that I assimilated into the matrix with a focus on science and an understanding that it would be appropriate for outdoor learning. These ideas developed from:

- A Times Educational Supplement professional resource (TES 2013) for teachers to use as a guide to write success criteria focusing on critical thinking and Bloom's taxonomy (Bloom *et al*. 1956). This provided a structure and some key vocabulary for each category.
- The National Curriculum (GB.DfE 2013) statutory requirements for working scientifically. These were used to populate the matrix for it to be relevant to current practice in line with the key vocabulary for each category.
- The working scientifically aspects of progression in understanding from Ward and Roden (2016, p84-86) and assessment focus one from Assessing Pupil Progress in primary science (GB.DfE 2009). Although these were age-specific, my version included a spectrum of success criteria that prevented a ceiling being applied to learning according to age. Their aspects of progression included indoor specific criteria, such as written communication and graphical representation, however, mine were considered with a focus on learning in the outdoors.

It was designed to be non-prescriptive by providing flexibility and autonomy for teachers through offering them a structure to identify appropriate challenge and potential next steps. It was based on 'thinking scientifically' as the learning outcome with four associated links to learning being: ideas, problems, evidence and questions. These links were allocated success criteria which were divided into 6 areas based upon Bloom's taxonomy (Bloom *et al*. 1956). These areas, ranging from knowledge to evaluation, were progressive in nature. As can be seen in section 3.3, Bloom's taxonomy (Bloom *et al*. 1956) had the potential to give children the opportunity to build on prior learning, whilst also enabling trainees to recognise progress and identify the children's next learning steps. Whilst it has been criticised for its hierarchical nature and lack of connection between elements, it provided the flexibility that 'set stages' would not and made the intangible less abstract. They allowed the user to assess children's scientific achievements and provided supportive next steps to enable the children to make progress. In this research, progress is seen as the achievement of success criteria in order to move towards a desired, improved and refined state (Main 2022).

In the trainees fourth year, they incorporated the matrix into lesson planning, where the learning outcome and success criteria were identified and used whilst facilitating children's learning as it occurred outdoors. Examples of the children's learning were collected to illustrate competence within the success criteria. Then the results were evaluated to assess the extent to which the children were meeting the objectives of the lesson, as can be seen in the annotated 'thinking scientifically' matrix (Figure 9). These results were then used in future planning and the setting of expectations for the children, which changed over time.



Learning outcomes	Links to teaching	Success Criteria					
		Evaluation	Synthesis	Analysis	Application	Comprehension	Knowledge
Thinking scientifically	I - Ideas	☐ Use abstract ideas or models or multiple factors when explaining processes or phenomena 🟨🟦🟪	☐ Use abstract ideas or models or more than one step when describing processes or phenomena 🟪🟨🟥🟦	☐ Use scientific ideas when describing simple processes or phenomena 🟦🟪🟨	☐ Identify differences, similarities or changes related to simple scientific ideas, processes or phenomena	☐ Draw on their observations and ideas to offer answers to questions 🟦🟪🟨🟥	☐ Ask questions stimulated by their exploration 🟪🟦🟥🟨
	P - Problems	☐ Identify the strengths and weaknesses of particular models	☐ Explain processes or phenomena, suggest solutions to problems or answer questions by drawing on abstract ideas or models 🟨🟦🟥🟪	☐ Use simple models to describe scientific ideas 🟨🟦🟪🟥	☐ Respond to ideas given to them to answer questions or suggest solutions to problems. Represent things in the real world using simple physical models 🟪🟦🟥🟨	☐ Make comparisons between basic features or components of objects, living things or events 🟦🟪🟨🟥	☐ Recognise basic features 🟨🟥🟪🟦
	E - Evidence	☐ Describe some scientific evidence that supports or refutes particular ideas or arguments, including those in development 🟥🟨🟦🟪	☐ Recognise scientific questions that do not yet have definitive answers ☐ Identify the use of evidence and creative thinking by scientists in the development of scientific ideas 🟥🟨🟪🟦	☐ Identify scientific evidence that is being used to support or refute ideas or arguments	☐ Use straightforward scientific evidence to answer questions, or to support their findings 🟦🟥🟪🟨	☐ Sort and group objects, living things or events on the basis of what they have observed ☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) needed to answer a question	☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) that has been used to answer a question 🟨🟥🟪🟦
	Q - Questions	☐ Explain how new scientific evidence is discussed and interpreted by the scientific community and how this may lead to changes in scientific idea 🟨🟪🟥🟦	☐ Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience. ☐ Identify further questions arising from their results. ☐ Make predictions using scientific knowledge and understanding 🟨🟦🟥🟪	☐ Use their science experiences to explore ideas and raise different kinds of questions ☐ Use their results to make predictions 🟦🟪🟨🟥	☐ Raise their own relevant questions about the world around them. ☐ With support, they should identify new questions arising from the data, making predictions for new values within or beyond the data they have collected and finding ways of improving what they have already done. 🟨🟥🟪🟦	☐ Explore the world around them and raise their own simple questions 🟦🟪🟨🟥	☐ Draw on their experience to help answer questions. Show curiosity about objects, events and people. ☐ Question why things happen 🟨🟥🟪🟦

drawing their snails + labelling

using printed labelled snails to check understanding

looking at snails in magnifier

saying what parts of a snail are used for what

asking questions about how we might know this or why this is the way it is.

predictions from the choice chambers

answering q's on their KWL sheet.

habitat/ KWL

molluscs/ invertebrates/ diet.

🟨 Mi
🟪 M
🟦 J
🟥 A
Child code

🟧 targets for next time

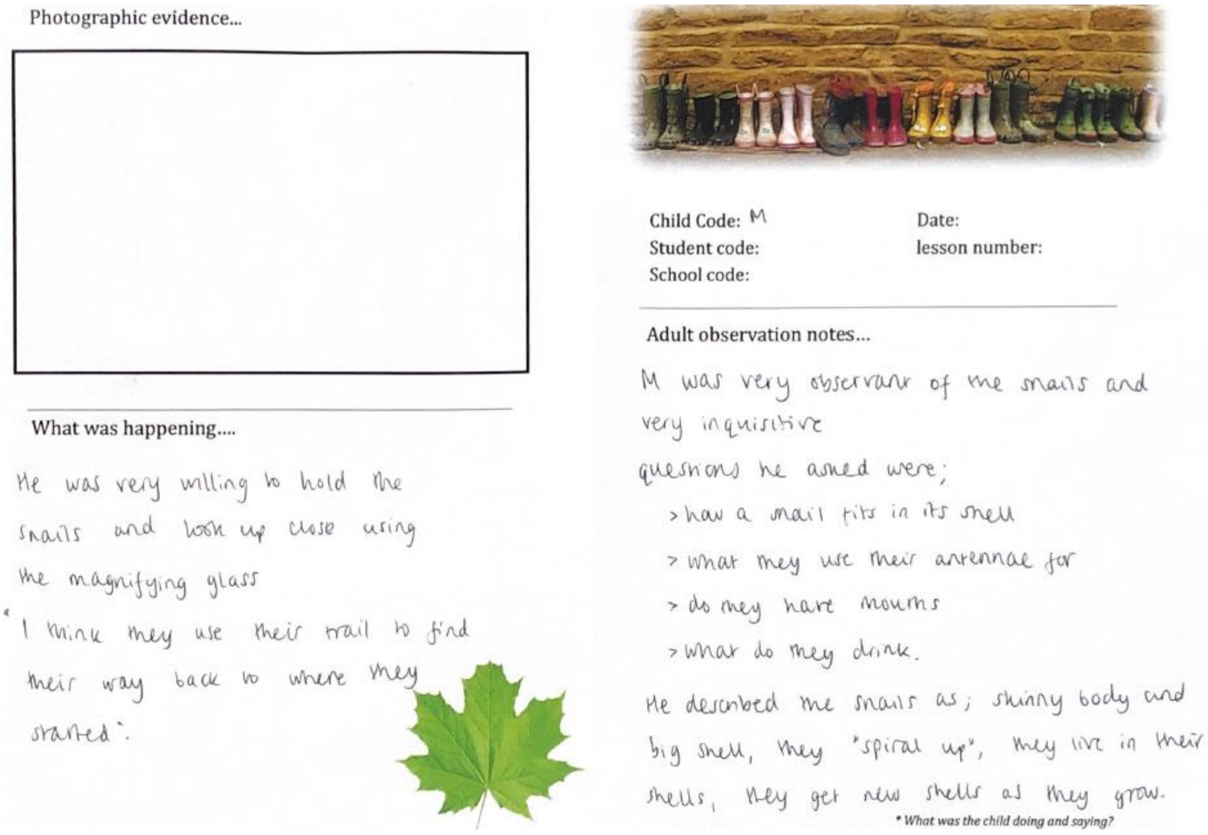
snails session 23/10/19.

Figure 9: Annotated 'thinking scientifically' matrix. The diagram shows how TR1 applied the matrix within their practice.

8.2 Pilot study

The purpose of the pilot was to reflect on the role of the trainee teachers as facilitators, try out the research tools and test the recording methods (Yin 2018). I wanted to understand the learning of the children that was occurring outdoors and I wanted to gauge the trainees’ ability to collect the data (Morrison 1993). It was beneficial to establish how feasible the recording methods and research tools would be to work with. I also needed to respond to the emerging data over the restricted data collection period for this to inform my future actions.

Before the development of the ‘thinking scientifically’ matrix, I originally designed and trialled a ‘working scientifically’ matrix in the pilot study. I modelled the use of both the booklets and the original ‘working scientifically’ matrix in a seminar which focused on the initial teacher training Core Content Framework (standard 1iii and 4vi) (GB.DfE 2019a) involving expectations and providing challenge along with the use of questioning. A completed example of the booklet was shared with them (Figure 10, Appendix 1) and time was spent discussing the potential of the tools, logistics of use, consistency in expectations and interpretation.



Photographic evidence...

What was happening....

He was very willing to hold the snails and look up close using the magnifying glass

"I think they use their trail to find their way back to where they started".

Child Code: M
Date:
Student code:
lesson number:
School code:

Adult observation notes...

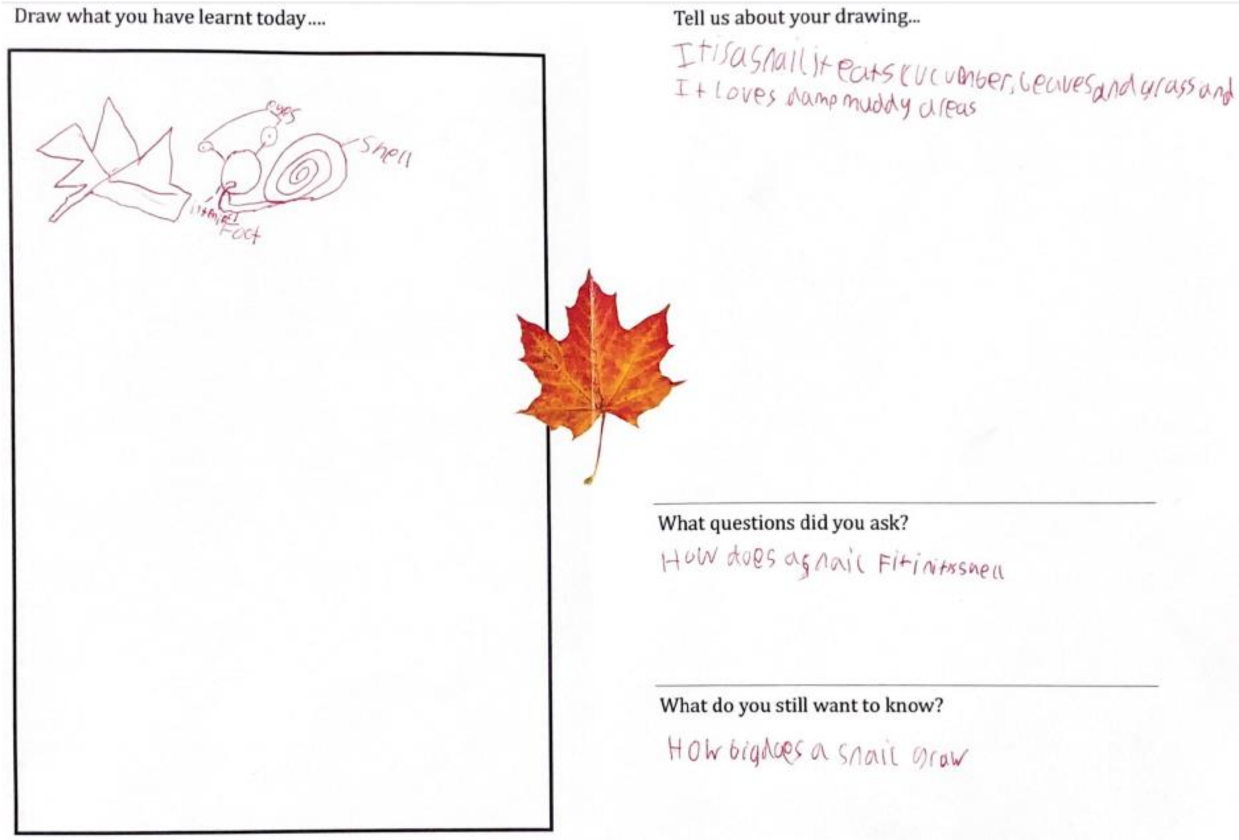
M was very observant of the snails and very inquisitive

questions he asked were;

- how a snail fits in its shell
- what they use their antennae for
- do they have mouths
- what do they drink.

He described the snails as; shiny body and big shell, they "spiral up", they live in their shells, they get new shells as they grow.

* What was the child doing and saying?



Draw what you have learnt today....

Tell us about your drawing...

It is a snail it eats cucumber, leaves and grass and
It loves damp muddy areas

What questions did you ask?

How does a snail fit in its shell

What do you still want to know?

How big does a snail grow

<u>Figure 10</u>: Completed 'learning in action' booklet (Appendix 1).

The trainees trialled the completion of a blank version with peers alongside input on plant reproduction and through their engagement with the dissection of fruits and seeds. The matrix was then used to make judgements about the evidence and guided the decisions about the next steps in learning.

The pilot study took place at the university, with 60 third year trainees who were studying for the BA in Education degree with QTS. They were studying in their fourth year at the time of the main study. This was part of their usual module experience. They were working with year 5 children (9-10 year olds) from a local primary school. They used the 'learning in action' booklet as their recording method to collect evidence of learning (Figure 7). The trainee teachers became familiar with my original 'working scientifically' matrix (Appendix 3) in the pilot through their third-year module. It consisted of four overarching areas that were taken from the National Curriculum 'Working Scientifically' foci including: thinking scientifically; communicating and collaborating in science; using investigative approaches; and working critically with evidence (GB.DfE 2013). It was used to guide learning expectations and assess learning successes.

As there was an expectation that the trainees and children would take part in the learning activity in line with the usual module requirements, ethical considerations were employed to enable integrity and transparency (Appendix 4). Consent was requested from all of the trainees and from the children, parents or carers and school (ethics section 9 and Appendix 5a, 5b, 5c, 5d) so they understood what the research was about and how the data would be used within the research.

The trainee teachers were provided with the following instructions:

- Design an outdoor activity to challenge a group of more able year five children (age 9-10) and ensure the links to science in the National Curriculum (GB.DfE 2013) and especially 'working scientifically' are clear.
- Capture the evidence of learning to include the children's thinking using the 'learning in action' booklet e.g. note critical incidents, capture questions, take photographs, encourage children to take photographs, draw and describe their ideas.
- Use the 'working scientifically matrix' as a resource to support planning and assessing the learning in line with National expectations.
- Evaluate the success and potential of the task. Consider how the learning was personalised and how the children's thinking was extended.

I then interviewed 12 trainee teachers who had completed the module in their third year in two focus groups (Cohen, Manion and Morrison 2011). They reflected on the successes and challenges of collecting and recording the results, using the booklet (Figure 7), as well as setting expectations and the application of success criteria, using the original 'working scientifically' matrix (Appendix 3). Small group sizes aimed to limit the impact of a dominant voice and the influence and peer pressure. The interaction and group dynamics were valuable in sharing opinions about the shared experiences. Notes were taken during the interviews to capture the central issues whilst being mindful of recorder bias and distractions (Nunan 1992). The questions from the group interview schedule were shared with each group as a whole and then discussed at the trainees' convenience (Appendix 6).

Using the university wide evaluation tool called EvaSys, I also collected questionnaires from 46 of the 60 trainees for broader feedback on their experiences and for a better representativeness of the views across the cohort (Bell 1993). It used a four-point scale to capture the trainees' agreement about their ability to manage the learning (Appendix 7). It also provided opportunities for more detailed qualitative feedback and key learning examples through the open questions at the end. Closed questions focused on expectations, enquiry skills, data collection, contextualised learning and evaluation as well as the success of specific teaching approaches that were included in the taught module. The trainees had the opportunity to articulate the learning and provide examples to support this in a qualitative way, through the open questions. The intention was to enable free and honest responses (Wellington 2000).

Within the findings, the trainees feedback showed that the outdoor experiences were beneficial. Positive comments, including 'ease of use', confirmed the value of the approach chosen in the research (Appendix 8a). The findings that were relevant to the main study highlighted four key implications for the research.

8.2.1 Implications from the pilot

This was a developmental process resulting in the re-design of the 'thinking scientifically' matrix and the effective application of the 'learning in action' booklet within their practice. As a consequence, I was able to adjust and re-shape the expectations for the main research based on four recommendations: developing routines, managing expectations, focusing on the evidence of learning and using the refined matrix.

The pilot showed that it was necessary to develop *routines* to enable data to be collected 'in-the-moment': taking booklets or paper outside to draw, having school cameras available for trainees' and children's use, recording critical incidents and dialogue, including recording questions. In the pilot, the trainees found this challenging to achieve at the same time as managing the learning (Appendix 8b). This resulted in the trainees' having an increased awareness of the importance of routines within the main study and were better prepared to deal with both the data collection and the learning.

In many cases there was also a change to the trainees' teaching and learning *routines*. In line with the experiential approach of this research, it was necessary for the trainees to find a balance between the level of scaffolding and child-led learning within the outdoor sessions (Appendix 8c). This was crucial to enable curiosity and purpose, to provide the freedom for children to answer their own questions and solve problems, thereby promoting engagement. This issue of finding the balance was shared with the trainees in the pilot and continued to be a focus for the main study as their experience and confidence developed.

Expectations needed to be managed so that trainees were prepared to cater for a broad range of learning needs and learning outcomes. Due to the nature of the module experience the trainees had not previously met the children, therefore they found it challenging to personalise the learning without a knowledge of the children's needs and their prior learning (Appendix 8d). The pilot also showed that when the trainees understood the science expectations, the learning was more purposeful (Appendix 8e), and when the timing of the sessions allowed for reflection on the learning, it provided more opportunities to demonstrate critical thinking (Appendix 8f). In timing of the main study ensured that the relationships were established over an eight-week placement, the trainees had taken responsibility for wider science subject knowledge research and had more experience of understanding the children as holistic learners.

In the pilot, a focus group of trainees was convened to gather their perspectives of outdoor learning, develop the interview schedule questions and questioning techniques (Appendix 6). The interviews provided a valuable perspective in the trainees' reflections but there was limited depth and detail, including generalised examples of the children's learning (Appendix 8a). Considering this, interviews were conducted individually in the main study and the question schedule included semi-structured questions to enable greater depth in trainees' reflections (Wellington 2000). My questioning techniques were also adjusted to be more open, interactive and valuing to allow the natural flow of conversation, with the intension of putting the trainees at ease (Patton 2002).

The trainee focus group interviews in the pilot also showed the importance of using the *evidence of learning* in the discussion to demonstrate achievement. The trainees' articulation of the learning was stronger when it included reference to a photograph or a drawing, for example, from the 'learning in action' booklet (Appendix 8b), by stimulating reasoning and deeper reflection in their examples. The trainees were able to include rich detail by connecting components within the experiences which would be difficult to uncover through other methods (Patton 2002). As a result, the *evidence of learning* was emphasised in the individual interviews within the main study and was used to triangulate corresponding interpretations and perspectives (Wellington 2000).

The original matrix that was designed for the pilot incorporated a wide range of 'working scientifically' aspects including: thinking scientifically; communicating and collaborating in science; using investigative approaches; and working critically with evidence (Appendix 3) in line with the National Curriculum (GB.DfE 2013) end of Key Stage outcomes. The trainees found it challenging to assess so many aspects within the learning (Appendix 8g). Due to the unwieldy nature of the matrix in the pilot, a *refined matrix* was designed to be more concise and accessible in the outdoors. It was amended for the main study to simply focus on 'thinking scientifically', with the links to teaching being: ideas, problems, evidence and questions (Figure 8, Appendix 2). These success criteria were more relevant because they supported child-led and experiential learning in the outdoors, as opposed to having a reliance on classroom-oriented outcomes, such as enquiries and testing.

The pilot raised the trainees' awareness of the challenges in facilitating the research, the time requirements and managing their workload, including the need for realistic group sizes to ensure the data collection was viable. As a result, they were better prepared for this in the main study.

8.3 The main study.

As previously discussed (section 7.3), the multiple qualitative case studies included 3 trainees, each one was a science specialist in a placement school, with between 3 and 4 children each. The children were from a range of age groups across the primary age range (5-11), 4 were age 5-6 and 7 were age 7-8. The trainees obtained ethical consent from their school, gate keepers and participants in line with the ethical clearance and model letters that were provided to enable consistency in ethical approach (Payne and Joyner 2006; Greig, Taylor and MacKay 2007). They then used the ‘thinking scientifically’ assessment matrix (Figure 8) and ‘learning in action’ booklet (Figure 7) within their practice to collect evidence of learning including children’s scientific ideas, problems, evidence and questions. This included the children’s observations in the form of drawings, questions, descriptions, reflections and photographs. In addition, they used their own observations and reflections to share the learning which was documented within the interviews.

8.4 Documentary analysis

Documentary analysis can be viewed as a valuable data collection strategy for case studies as they are examined and interrogated in context (Briggs *et al.* 2012). Within this study, the evidence for documentary analysis was collected from two different sources: the ‘learning in action’ booklets and evidence from the trainees’ formative assessments. The ‘learning in action’ booklet provided the *children’s evidence of learning* and was collected for documentary analysis during the lessons. The evidence of learning was deemed to be significant when it showed that something was completed unaided or with help which they were unable to do without; when they took risks or recognised errors and misconceptions; when they were immersed; or when there was a shift in their understanding. The *evidence from trainees’ formative assessments of the learning* included field notes, transcripts and lesson evaluations. They were captured in-the-moment and the assessment evidence was used to feed forward into future learning.

The booklets also supplemented other data collection methods through triangulation and highlighted a range of perspectives including that of the child and the trainee teacher. They allowed access to information that would have been difficult to gain via interview by capturing the learning at the point when it occurred. The immediacy provided reliability and the potential for greater detail. They were used as part of the children’s usual learning experience with the intention of being unobtrusive.

***Children's evidence of learning*.** Children's drawings, questions, descriptions, reflections and photographs from the 'learning in action' booklets.	Children were involved in the collection of documentary evidence which demonstrated learning. Their involvement helped me and the trainees to understand what they saw, did and thought through the co-construction of meaning (Clark and Moss, 2011). The method was chosen to empower the children by enabling them to record and explain their thinking.
***Evidence from trainees' formative assessments of the learning*.** Field notes, transcripts, photographs of children and lesson evaluations.	Trainees added to the booklets, by scribing for the children, in order to support the children's recording skills. They were able to record both the learning in-the-moment and their reflections on the learning at the end of the lesson. This then enabled assessment to inform planning for progression (Wiliam and Black 1996).

8.5 Observations

Observations reveal learning potential as well as learning achievements (Nutbrown 2011) and are a valuing and holistic form of assessment that fit in with the learning context (Carr 2001). They recognise the child's voice and acknowledge the complex and social nature of learning. Within this research, observations were used both as a pedagogical tool and as a research method. The pedagogical tool involved observations *by* the children and were recorded in the 'learning in action' booklets. The research method involved observations *of* the children and were recorded in the trainees' formative assessments. They were used to capture the learning and make it visible (Hammersley and Atkinson 1983), with the assumption that they should be non-judgemental, factual and accurate.

In carrying out observations in research, one underlying assumption is that we can obtain reliable knowledge and understanding via our senses. Context-sensitive learning provides meaningful experiences (Land *et al*. 2015) and rich opportunities for collecting observational evidence. The focus of the observations within this research was on the demonstration of and development of scientific skills and understanding. Critical incidents (Tripp 2012) and critical events (Wragg 1994) are particular events or occurrences that typify or illuminate a particular feature of the learning within the observations. Critical incidents reveal something unusual or non-routine, such as risk-taking, a shift in understanding, misconceptions, the application of understanding, or a curious attitude, all of which are significant in this research. They were identified in-the-moment but also became evident through reflection.

Observations by the child. Providing opportunities for the children to take photographs and create drawings enabled the children to be observers and explainers of scientific phenomena. They were able to link their sensory experiences with scientific knowledge in order to represent their understanding. The children used mobile devices for photo-capture and to support their articulation and explanation building. This child-centred approach enabled the trainees and myself to better understand the child's viewpoint. The methods provided a 'viewfinder' to enable the learner to see or 'take notice' of the subject and its related phenomena in new ways (Eberbach and Crowley, 2009). The engagement and learner agency through the ownership of the learning was used to empower them to make decisions. The choice of what constitutes evidence of their learning promoted self-efficacy (Bandura, 1977).

Observations of the child by the trainee teacher. Teachers are said to be natural observers (Burton and Bartlett 2009) and similarly, the trainee teachers, used the skill of observation to make assessments as part of their reflective practice in-line with experiential learning cycle theory (Kolb 1984; Schon 1991). They collected illustrative examples of the children's skills and provided data linked to their involvement in the learning incidents. They utilised unstructured-participant observations with the children (Hammersley and Atkinson 1983; Woods 1986). The trainees were immersed in the situation as indigenous insiders (Smith 1999). The critical incidents that they captured were focused on constituent parts that combined to contribute to the whole learning which was articulated through the interviews.

8.6 Interviews

Interviews with teachers were used as an ‘inter-view’, an inter change of views between two persons conversing about a common theme (Kvale, 2007) leading to a shared understanding. The understanding was located within the interview and both the interviewer and interviewee came to a new understanding as a result of the interaction. In terms of interviewees within this study, each trainee was assigned a code, for example, trainee teacher 1 was referred to as TR1.

Learning conversations with the children by the trainee teachers	The children commented on the learning that was captured in two ways by the trainee teachers. Firstly, in-the-moment through annotations in the booklet and secondly when reflecting on the learning after the learning event. As a pedagogical tool, it also provided opportunities for more authentic and challenging reflections. This involved exploration or new knowledge creation, where what was held as a ‘truth’ could be questioned (Earl and Timperley, 2008).
Semi-structured interviews with trainee teachers	I explained the purpose of the interviews and their ethical rights in-line with the BERA (2018) guidelines, including having the right not to answer a question. Verbal and non-verbal techniques were used to prompt and allow the participant to feel at ease during the interview with each trainee. The semi-structured approach enabled the participants to have some freedom and to have some control over the agenda. I facilitated the participants’ responses through a naturally occurring, shared conversation

(Hammersley and Atkinson 1983; Silverman 2016). Self-reflection and freedom to elaborate on their experiences was promoted. I intended to use an audio-recorder to record interviews and make notes in-the-moment although, due to the COVID-19 restrictions, this was facilitated online through the use of Microsoft Teams. The questions were asked in themes and started with simple questions becoming progressively more complex (Wellington 2000). There were questions relating to the documentary evidence and observations, where annotations and articulation of learning evidence was used to triangulate the observations (Appendix 9). These acted as a vehicle for reflection within the interview.

8.7 Sampling

As previously discussed (section 7.3), this research was not aiming to achieve reliable data or discover a 'truth' in light of the findings. The intention was to gain a better understanding of the scientific learning that was occurring outdoors. In order to do this, two perspectives were sought. One at university level for the trainees and the other at school level for the children. *Volunteer sampling* (Morrison 2006) was used to identify the three trainees and their corresponding schools. I invited them to contribute based on a genuine interest; even though this may have had implications for capturing a true range of evidence and perspectives. The benefit of working with science specialists, alongside children in their natural learning environment, was their commitment to the subject and strong subject knowledge, which supported their understanding of the learning that was being observed. Before volunteering, the primary trainee teachers needed to demonstrate an interest in teaching and learning within outdoor science. They chose to specialise in science or outdoor learning within their final two years of the degree and opted for the Master's module, highlighting an interest in being a researching professional in their early careers. The schools accepted the final year degree trainee teachers and had an understanding of the learning philosophy embedded in this study. The head teacher and other teaching professionals within the schools were committed to enabling the research to occur.

In terms of the children, *purposive sampling* (Teddlie and Yu 2007) was used to select three to four children, who were *typical* for ages six to eight within the trainee’s class. This provided a range of ages, backgrounds and identifiable groups across the primary age phase. In using multiple-case studies, the sampling had a randomised element that was capitalised upon in the research, for example, when children were engaging in the learning, as a chance encounter or as an opportunity presented itself, such as a critical incident (Patton 2002; Cohen, Manion and Morrison 2011).

Ethics

I declare that this research has been subject to ethical review and received ethical approval from the following research ethics committee: Professional Doctorate Research Ethics Committee (PDREC) on 13th March 2019. I also declare that I have not deviated from the terms of the ethical approval issued by this committee.

9.1 Key underlying ethical principles

The underlying principles of educational research highlight a commitment to trust and honesty (Burgess, 1989). The ethical principles documented by Fulton and Costley (2019) were applied to this research to protect the rights of both the child and trainee participants (BERA 2018). This was detailed in their letter of consent (Appendix 5a, 5b, 5c, 5d) and ethical approval (Appendix 4). Key policies including the United Nations Rights of the Child (UN 1989, article 3), the Equality Act (2010) and the professional guidelines for teachers (GB.DfE 2011) were consulted to enable children to be valued inclusively and to ensure that they were respected and trust was upheld. Ethics were key to enabling practice and research to work together in a synergistic manner (Mockler 2014) and ethical approval was sought for this research from NTU, in-line with the BERA guidelines (BERA 2018).

9.1.1 The principle of beneficence

Outdoor learning was captured practically, with the aim to effectively support pedagogy and provide recommendations for children, trainees, teachers and leaders. Recommendations for my own practice were also made as a consequence of this research. It was my responsibility to disseminate the findings with a wider audience to enable others to benefit from the findings, thereby impacting upon future educational practice.

9.1.2 The principle of respect for autonomy

Involvement for all participants was voluntary. It was essential that the children, trainees and participating placement schools understood and accepted that they had the right to refuse to participate at any time during the research process. They also had the right to withdraw without affecting the researcher-participant relationship or participant-participant relationships. The university-school relationship was also not affected if a school was not in a position to enable a trainee to complete their data collection. In order to limit any potential distress, which may have been caused as a result of peer pressure, I did not tell the participants if anyone chose to withdraw their data. It was necessary for all participants to feel enabled to decline taking part and for children, in particular, to be able to make informed decisions regarding their participation. Acknowledging children as a vulnerable group, it was necessary to ensure that they were willing to participate and were able to do this in a safe and valuing way. It was also important for the trainees and myself to be vigilant for signs of anxiety and issues with self-esteem. Handling these subtleties sensitively, enabled participants to maintain the confidence to contribute ideas or initiate their right to withdraw (BERA, 2018), which they could do directly or via a responsible adult.

9.1.3 The principle of justice

Two different approaches to informed consent were required. One was from the trainee teachers in their roles as facilitators of the research and as participants, whilst the other one was from the children, parents or carers and schools (Appendix 5a, 5b, 5c, 5d). Consent from the children’s parents or carers was needed to take part and the head teacher was able to act in loco-parentis where it was deemed necessary. The purpose ‘for’ and manner ‘in which’ the data was collected, stored and processed was also explained in the letter of consent (Appendix 5a, 5b, 5c, 5d). The schools, trainees and children were anonymous and codes were used for the confidentiality of each of the cases. Data was managed confidentially, in line with the data for the General Data Protection

Regulation (GB.ICO 2018) including the storage and analysis of data such as images of children working outdoors. All participants were informed that the data was stored using password protected software (Appendix 10: data management plan). Sensitivity and confidentiality were used when handling personal documents or reflections, and these will be destroyed upon successful completion of the study. Transparency was maintained and the children were informed of the intentions and findings. Feedback and opportunities to share the initial findings were made available to the children, parents or carers and schools. The research dissemination will be through meetings, research conferences, publication and taught content on the BA in Education degree with QTS. Having informed consent permitted the inclusion of the data to support the depth and breadth of the findings and enabled data analysis to be more reliable.

9.1.4 The principle of non-maleficence.

The risk of harm in relation to the data collection was minimised through a range of strategies. I had already established professional links with the *trainee teachers* after teaching them for three years (Mukherji and Albon, 2010). I endeavoured to develop a rapport with the trainee participants to support my ability to look for signs of discomfort, distress and any sense of intrusion. The ‘bureaucratic burden’ of the research was taken into consideration and the impact on the trainees’ and teachers' everyday workloads was minimised. In terms of the risk to *children*, there was an expectation that the trainees, in their role as facilitators, had already established trainee-child relationships having taught them on placement. The research took part within their usual learning experiences with the intention of putting them at ease. Risk assessments were completed for all sites and activities, including assessments of child-initiated activities. Children had the choice of activity in-the-moment and were not expected to partake but involvement was encouraged along with their usual learning expectations. Another responsible member of staff, who was known to the children, was in attendance during the research involving the children to prevent 1:1 ratios occurring. In line with the safeguarding practices of the schools, the trainees had Disclosure and Barring Service (DBS) checks in place (GB.DfE 2022b). The subtleties and complexities of the children’s needs were supported by the trainees' inclusive pedagogy, which had been informed by the inclusion module and safeguarding assessment as part of their teacher training and focused on keeping children safe in education (GB.DfE 2022b). As a result, an awareness of age, intellectual capability and vulnerability, informed the adaptations and personalisation of approach, in order to support authentic responses.

9.2 Ethical decisions relating to positions of power

When considering research relationships, at times there was the potential for an imbalance of power which needed to be addressed within a reflexive approach. In order to mitigate this, it was necessary to firstly develop a less hierarchical relationship and secondly to ensure assessments were not influenced by their involvement in the research. In terms of hierarchy, I was seen as an ‘indigenous insider' by the trainees whilst they were studying to be practitioners. In my role as a science senior lecturer, I had taught them for their science module and went on to lead on their research skills module for their independent study. Regular fortnightly meetings enabled them to feel at ease and allowed them to share views and contribute to a common alignment of principles. Through my involvement with the assessment process, rigour in marking was provided through cross-course moderation (Appendix 11a, 11b, 11c) and by following the university's marking and moderation process, which was over seen by external examiners from other institutions (NTU 2020). The interviews were conducted after the final degree results were released and were timed to be post-qualifying in order to minimise researcher bias (Wellington 2000).

At every stage, ethical reflexivity was needed to enable me to consider my actions in line with my morals and values which were defined in my philosophy in section 1.1. In summary, there was an element of trust in terms of the ethical approach. Time was taken to share my moral stance and my own values with participants. There were procedural ethics that were followed with clear requirements and a focus on sensitivity. Micro-ethical principles (Fulton 2019) were also considered which involved subtleties, complexities and ethical dilemmas (Guillemin and Gillam 2004); highlighting the importance of the principles that needed to be followed by myself and the trainees as facilitators.

Data analysis

10.1 Analytic strategy

The qualitative data was generated through documentary analysis, observations and interviews. The analysis enabled me to describe and interpret the evidence, as well as identifying meaning through recognising patterns and generating themes. My approach to data analysis was informed by Glaser and Strauss (1967) alongside Wellington (2000), whose data analysis methods were used to develop four stages of analysis that align with my research. The set of stages that I created supported organisational sense-making and included both inductive and deductive aspects (Miles and Huberman 1994). It followed an inductive, bottom-up approach from stage one to three (Glaser and Strauss 1967). This provided me with a structure for the interpretation of the evidence of learning, working in an exploratory way from the raw data to derive codes, themes and concepts (Thomas 2006). It also included a deductive approach at stage four (Gale *et al.* 2013; Azungah 2018). This enabled a deeper level of analysis through the use of an organisational framework, based on core concepts and pre-existing theory. Whilst the stages show progressive depth and increasing academic rigour, there was also some shifting between the stages for example some revisiting of immersion and reflection to revisit points of interest or look for reoccurrence and repetition.

- **Stage 1:** Immersion in and reflection on the learning (inductive).
  This involved getting an overall sense for the data from the trainee reflections and evidence of learning. It also included selecting and filtering the data. It was evidenced through the initial notes (Appendix 12a, 12b, 12c).
- **Stage 2:** Open coding and thematic analysis (Cohen, Manion and Morrison 2011) within-case studies (inductive).
  This involved cognitive mapping, seeking patterns and looking for casual pathways and connections. It was evidenced through the mind maps (Appendix 13a, 13b, 13c).
- **Stage 3:** Recombining and synthesising in cross-case analysis (inductive).

  This involved further coding and identifying patterns between cases. It encompassed the identification of regularities and contrasts leading to connections and meaning making. It was evidenced through the sub-theme grids (Appendix 14).
- **Stage 4:** Higher level synthesis through classification (deductive).
  This involved the application of theoretical models to the practice-based decision making and analysis. It encompassed continued sifting, sorting, reviewing and reflecting on the data, which enabled the identification of sub-elements. It was evidenced through the matrix analysis and question analysis (Appendix 15).

The patchwork nature of this analytical approach, which involves building a 'collage of incidents' through reflection (Winter 2003 and Ovens 2011), was personalised to accommodate the individual needs of the trainees and their children. It resulted in a unique combination of findings. It involved taking a reflexive approach and facilitating the opportunity for the trainees to reflect on the learning in addition to their daily teaching and assessment. This reflection enriched learning when it built upon the evidence. Stitching together the patchwork cemented and enhanced learning from the individual data collection points and each of the three cases. It provided greater detail about the learning because the reflection on the tasks, process, achievement and feedback were combined. The thematic approach to analysis suggested that the patchwork approach increased self-awareness and insight; deepening and promoting on-going reflection (Moen and Brown 2017).

10.1.1 Stage 1 – Immersion in and reflection on the evidence collected

Immersion and reflection involved getting an overall sense for the data, hearing what the evidence had to say and standing back from the data (Wellington 2000). It was interrogated by searching for patterns, insight or concepts, such as scientific vocabulary, common ideas, misconceptions and anomalies. I followed the approach of Glaser and Strauss (1967) who suggested to look for regularities, patterns, explanations, possible configurations, casual flows and prepositions. The evidence of the learning, taken from the booklets, was annotated and reflected upon. Key aspects were 'selected and filtered' (Glaser and Strauss 1967) to support the points that the trainees made. The evidence was used by the trainees to prompt their memory or exemplify their point during the interviews. The interpretation of observations, drawings and photographs needed to accurately capture the children's actions, ideas and attitudes, enabling the conclusions to be increasingly clear (Riley 1990; Rubin and Rubin 1995). The trainees' perspectives supported the validity of my interpretation (Mishler 1991) and were considered ethically (section 9) with openness and scepticism.

10.1.2 Stage 2 – Open coding and thematic analysis and *within* a case-study

Analytic strategies were used across data collection methods within each case study to explore connections, contrasts and comparisons. These included: cognitive mapping (Jones, 1987; Morrison 1993), seeking patterns of responses and looking for casual pathways and connections (Miles and Huberman 1994). The mind-maps (Appendix 13a, 13b, 13c) were used as a form of cognitive mapping (Miles and Huberman 1994) to interrogate the data and connections were made between the points that were discussed for each case. The points were organised into stems and branches to establish in-case triangulation. The data was refined and details that were relevant to the research focus were highlighted through colour coding in a form of open coding and thematic analysis (Cohen, Manion and Morrison 2011). Figure 11a and 11b display an example of thematic analysis from the interview with trainee TR2 where assessment was the starting point and examples such as capturing evidence and independence to address misconceptions branched out from this initial focus with further depth, detail and examples that were discussed.

The reflection on the children's learning allowed coding to be applied (Miles and Huberman 1994) and themes to be identified (Appendix 13a, 13b, 13c). The themes were highlighted through the colour coding on the mind-maps including: thinking scientifically (orange); behaving scientifically (blue) and questioning scientifically (green). These themes were most relevant to the research question and were analysed in the discussion. There was an awareness that non-selected elements had value and were revisited through repeated analysis. Some of the points, for example on the role of the adult (brown), were captured for future analysis.

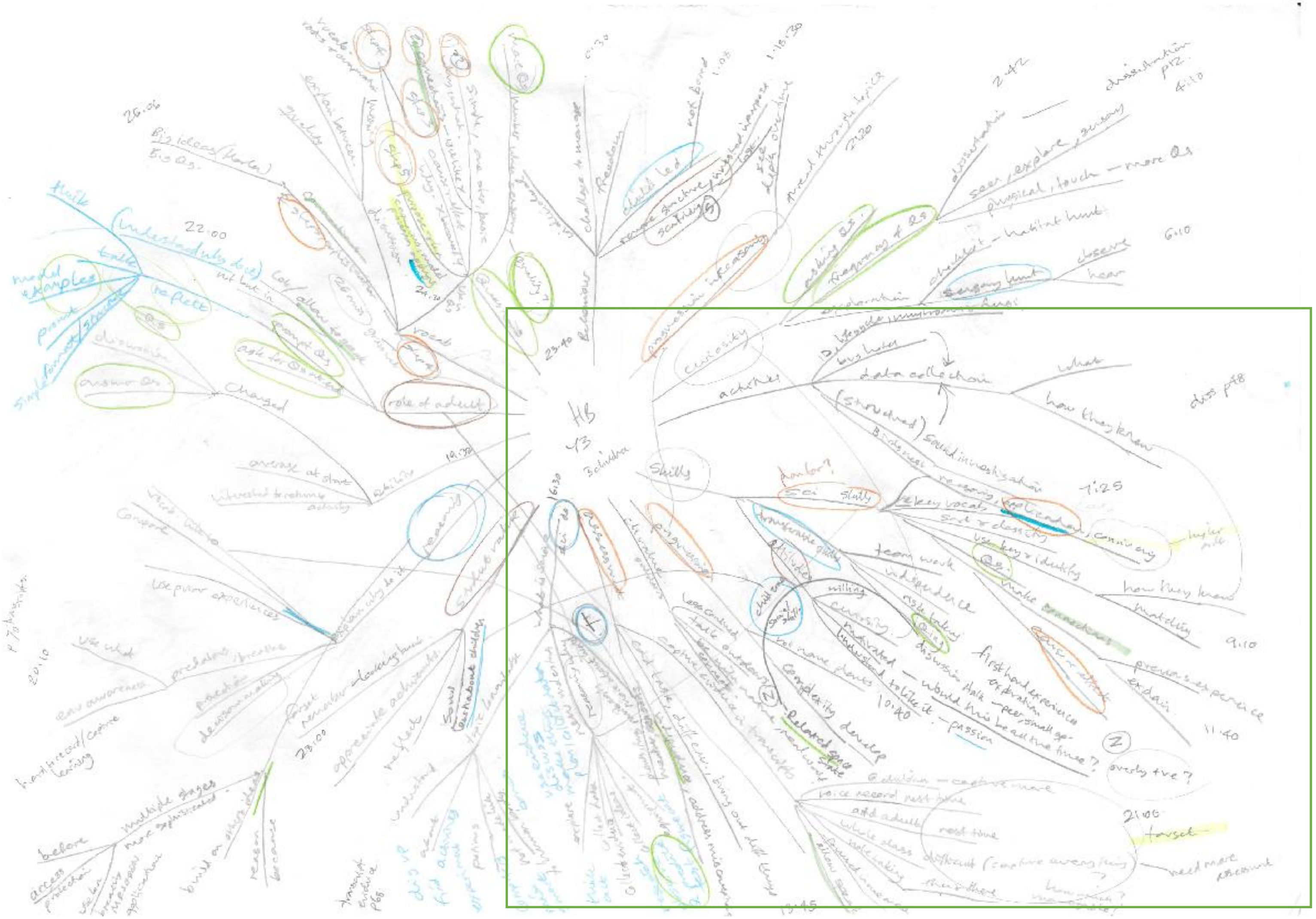


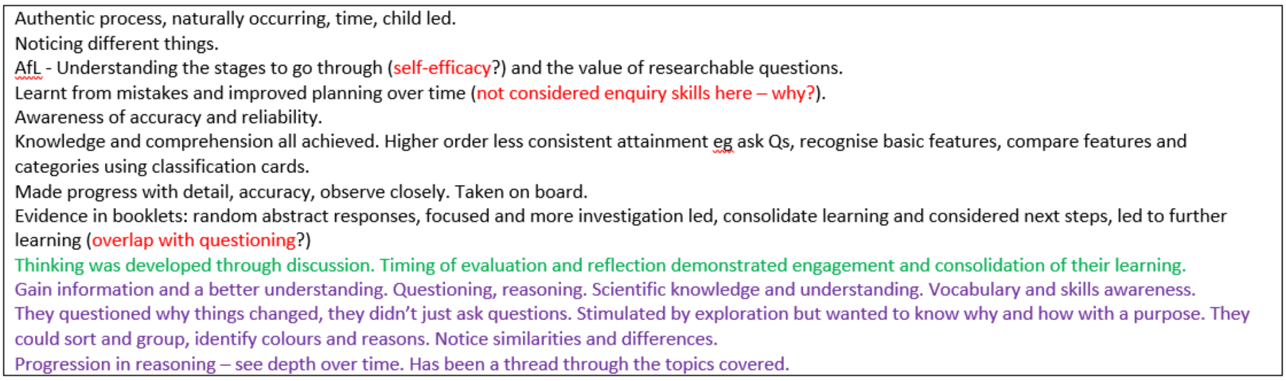
Figure 11a: Thematic analysis within a case study. The colours represent cross-case coding (Appendix 13b).

Figure 11b: **The colours represent cross-case coding. Thinking scientifically (orange); behaving scientifically (blue) and questioning (green).**

10.1.3 Stage 3 – Recombining and synthesising involving cross-case analysis.

Recombining and synthesising data (Glaser and Strauss 1967) through continuous refinement of the evidence was used to compare and contrast the case study findings from different trainees working in different schools with different children. The data was triangulated *between* the three case studies, drawing upon the trainees' examples of children's learning and care was taken not to directly compare schools and the achievements of individual children (Greig, Taylor and MacKay 2007). The colour coding was used consistently across the mind-maps *between* the cases. As in stage 2, the constant comparative method of analysing qualitative data (Lincoln and Guba 1985) involved searching for patterns, themes and regularities in the data as well as looking for contrasts, paradoxes and irregularities (Delamont 1992).

The synthesis enabled layering of the data to evidence the depth and complexity involved, providing greater validity within these themes. Refinements were made according to the connections across all three cases, as can be seen from the tabulated example (Figure 12, Appendix 14), where each case is represented by a different colour (green TR1, purple TR2, black TR3). These were the areas of significance that were most prominent in the trainee's evidence and supported a response to the research questions. The points in red show the interrogation that identified contrasts, paradoxes and irregularities.



Authentic process, naturally occurring, time, child led.
Noticing different things.
AfL - Understanding the stages to go through (self-efficacy?) and the value of researchable questions.
Learnt from mistakes and improved planning over time (not considered enquiry skills here – why?).
Awareness of accuracy and reliability.
Knowledge and comprehension all achieved. Higher order less consistent attainment eg ask Qs, recognise basic features, compare features and categories using classification cards.
Made progress with detail, accuracy, observe closely. Taken on board.
Evidence in booklets: random abstract responses, focused and more investigation led, consolidate learning and considered next steps, led to further learning (overlap with questioning?)
Thinking was developed through discussion. Timing of evaluation and reflection demonstrated engagement and consolidation of their learning.
Gain information and a better understanding. Questioning, reasoning. Scientific knowledge and understanding. Vocabulary and skills awareness.
They questioned why things changed, they didn't just ask questions. Stimulated by exploration but wanted to know why and how with a purpose. They could sort and group, identify colours and reasons. Notice similarities and differences.
Progression in reasoning – see depth over time. Has been a thread through the topics covered.

Figure 12: This shows one of the thinking scientifically sub-themes 'how thinking changed'. It demonstrates how the data was synthesised. There is evidence from three cases relating to how the children's thinking changed (green TR1, purple TR2, black TR3, red initial interrogation).

A continuous refinement of evidence was used to draw conclusions from both the data within-cases and across-cases. It involved continued sifting, sorting, reviewing and reflecting of the data until sub-elements were identified (Glaser and Strauss, 1967). The themes of 'thinking scientifically', 'behaving scientifically' and 'questioning scientifically' were generated from the data analysis as a whole and formed the chapters within the discussion of this thesis. They were significant within each case and across all three cases. Prominent sub-themes were then identified as most relevant in responding to the research questions. The sub-themes were common across all three mind-maps and were identified when the evidence was brought together in the combined evidence table (Appendix 14). In order to provide greater validity, patterns were explored, points were questioned and gaps were noticed (Lincoln and Guba 1985). Different approaches were acknowledged and critiqued through further reflection and location within the literature and research.

Thinking scientifically was a significant theme (Figure 13). It was an over-arching theme cross all three cases that had many facets. There was a clear desire from the trainees to demonstrate changes in the children's thinking and higher order thinking skills.

Sub-themes within thinking scientifically:

- Knowledge and understanding
- Application and prior knowledge
- Higher order thinking skills
- Child-led learning and ownership
- How thinking changed
- Expectations
- Metacognition
- Challenge

Figure 13: These sub-themes were generated within the thinking scientifically theme (orange colour on the mind map).

Behaving scientifically was the second significant theme (Figure 14). It encompassed a variety of actions and approaches to the learning. While the scope was varied, I focused on the aspects that were most closely aligned with the National Curriculum (GB.DfE 2013).

Sub-themes within behaving scientifically:

- Observations over time
- Identify and classify
- Articulate scientific behaviour
- Problem solving
- Attitudes
- Curiosity

Figure 14: These sub-themes were generated within the behaving scientifically theme (blue colour on the mind map).

Questioning was the third significant theme (Figure 15). The trainees were able to articulate and provide evidence for sub-themes such as types of questions, achievement and progression in children's questions. Whilst it bridged the themes of thinking scientifically and behaving scientifically, the examples of the children's questions and the depth of the reflective discussion about questioning provided substantial evidence to address the research questions.

Sub-themes within questioning:

- Questions underpinning child-led approach
- Question types
- Challenge and depth
- Progression in children's questions
- Choices and decision making
- Questions during post-learning reflection
- Questions in-the-moment
- Questions for assessment

Figure 15: This is an example of the sub-themes that were generated within the questioning theme (green on the mind map).

10.1.4 Stage 4 – Analysis of the data through higher-level synthesis.

Whilst qualitative methods tend to produce bulky, dense, complex data, and form thick descriptions, the result of analysis is higher level synthesis (Geertz 1973). This was also achieved through the application of success criteria and question classification. The analysis changed to a deductive approach by using frameworks to show the relevance of and connection between the variety of evidence both in-practice and post-practice. Two frameworks influenced this analysis, Bloom's taxonomy (Bloom *et al*. 1956) and Jelly (1985). They were used both as a pedagogical tool and an analytical tool. Pedagogically, they were used to identify points of significance from the learning generated through research. Analytically, they were used to organise the analysis of the data and structure the significant examples.

Firstly, Bloom's taxonomy (Bloom *et al.* 1956) informed the design and order of the success criteria within the matrix (Figure 16). There was an element of progression, ranging from knowledge to evaluation. The matrix was used formatively to support the identification of examples of attainment within the ongoing practice and in the final data. Evidence of learning correlated with the success criteria on the matrix.

Learning outcomes	**Success Criteria**					
	Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
Thinking scientifically	Use abstract ideas or models or multiple factors when explaining processes or phenomena	Explain processes or phenomena, suggest solutions to problems or answer questions by drawing on abstract ideas or models	Identify scientific evidence that is being used to support or refute ideas or arguments	Identify differences, similarities or changes related to simple scientific ideas, processes or phenomena	Make comparisons between basic features or components of objects, living things or events	Recognise basic features
Examples of learning evidence	*Taking their own experiences of things like the first frost and relating it to dormancy in the plant life cycle (TR3 44:11).*	*They were designing child-led enquiries deciding on their independent and dependent variables (TR3 47:07) including designing bug hotels (TR1 42:57). This linked to reasoning when discussing the location of the bug hotel in light of predators, access including for flying insects, breathability and appropriate material choices (TR2 1:00:39).*	*One recognised a plant was dying because of the seasonal changes and they needed sunlight to grow (TR2 11:42)*	*Running made her heart pump fast and she was using up oxygen resulting in her being out of breath (TR2 37:31).*	*Being able to explain the differences between fungi and plants (TR2 30:45) and colour change in dying and decaying matter (TR2 23:25).*	*Drawing mini-beasts and sorting them according to their features (TR3 06:37).*

Figure 16: This shows how the examples from the data related to a variety of the thinking scientifically success criteria which were adapted from Bloom *et al*. (1956).

Secondly, Jelly (1985) focused on how teachers should respond to different classes of questions (Figure 17). This framework was used within the research to support trainees' assessment of learning and subsequently was used to analyse the data in greater detail. When applying this framework, the evidence of learning in the form of children's questions, was classified in one of five ways. The categories were: i) comments as questions, ii) philosophical, iii) facts, iv) complex and v) investigable. The questions were categorised to organise and focus the subsequent interpretations and were not designed to be progressive. Within this analysis, those that were judged to be complex questions were further broken down following the structure suggested in Murphy, Gripton and McEwan (2021) to include, connection (A), and reasoning (B). The investigable questions that were raised were further classified through Goldsworthy and Feasey's (1997) definitions (Appendix 15).

Question type	Example
i) comments as questions	Why is the mud squashy?
ii) philosophical	What would happen if there was no sun?
iii) require facts	What tree has the leaf come from?
iv) complex	
complex A: connection	How do flowers grow where we don't plant them?
complex B: reasoning	Why do we have shadows?
v) investigable	
invest A: a question that tells you what to change (independent variable) and what to measure (dependent variable)	What sounds do birds make? Would the sound be small if the birds beak was small?
invest B: a question that tells you what to change, but you have to decide what to measure	Which way do you have to plant your bulb?
invest C: a question that tells you what to measure, but you have to decide what to change	How long does a bean take to rot?

Figure 17: This shows examples of the questions from cross-case analysis. They have been classified through the application of the literature.

10.2 Summary

Within my role as an external insider, I enabled the data collection through drawing upon a qualitative multiple-case study approach. The research made use of pedagogical tools and methods including documentary analysis, observations and interviews. The data was interpreted using open coding and thematic analysis, leading to refinement and deeper synthesis. The themes and categories helped to demonstrate the connections, patterns and regularities that had been identified in the learning. Within the analysis, I was interested in documenting patterns in the science skills being used in the outdoors by the children. Critical incidents were valuable in demonstrating learning in-the-moment (Tripp 2012). I used the themes and sub-themes from the analysis to identify a set of scientific dispositions including thinking scientifically, behaving scientifically and questioning scientifically.

When exploring what constitutes effective outdoor science learning, the data analysis highlights the importance of these dispositions which are tailored for primary science and outdoor learning. The data is used in a critical discussion of the analysis, making sense of the data through further reflection and by locating the data within literature and other people's research. The research questions were considered at every stage of the research design and the findings will be used to respond to the questions in the conclusion (Wellington 2000). As a result of the findings, the next steps will highlight the recommendations and the ongoing needs in relation to these themes.

Analysis and discussion

The data analysis revealed the ways in which outdoor learning for science education helps to provoke in children a set of scientific dispositions effective for primary science education. From outdoor learning endeavours, trainee teachers documented how children tended to be well-placed to:

- think scientifically (Chapter 1),
- behave scientifically (Chapter 2),
- develop a scientific line of questioning (Chapter 3).

Each of these scientific dispositions were found to build and support the development of children's scientific literacy. The children's ability to think scientifically in the outdoors involved ideas, problems, evidence, asking questions and reflection on the learning associated with the real world. The trainees (TR1[4], TR2[5], TR3[6]) showed that the ability to think scientifically had an impact on children's scientific behaviours. They found that behaving scientifically was where the children demonstrated scientific actions, attitudes and ways of working through the application of disciplinary knowledge. Scientific behaviour was also found to support and inform the children's ability to question in scientific ways, demonstrating higher order thinking.

The way in which these scientific dispositions surfaced was aided by the assessment criteria in the matrix that was informed by Bloom's taxonomic thinking (Bloom *et al*. 1956), which trainee teachers used to chart children's outdoor learning for science education. The following sections show how the themes of the three scientific dispositions developed through the application of the matrix.

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[4] TR1 means trainee teacher 1 and refers to the evidence from the interview in Appendix 16a
[5] TR2 means trainee teacher 2 and refers to the evidence from the interview in Appendix 16b
[6] TR3 means trainee teacher 3 and refers to the evidence from the interview in Appendix 16c

11.1 Chapter 1: ‘Thinking scientifically’ in the outdoors

In the context of this study, ‘thinking scientifically’ is used to refer to the cognitive processes drawn from learning that are associated with scientific knowledge. Examples of such include using ‘ideas’ to make decisions, solving ‘problems’, reasoning from ‘evidence’ and asking ‘questions’ about the real world. Using these key principles underpinning thinking scientifically, the trainees used the matrix as an assessment tool to show that the children, across the range of ages, in all the case studies achieved several criteria. This was within the categories of knowledge, understanding, application, analysis, synthesis and evaluation based on Bloom’s taxonomy (Bloom *et al*. 1956).

When learning outdoors, the children demonstrated higher order scientific thinking skills which the trainees associated with the matrix. There was clear progression in their thinking that led to metacognition, through an increased awareness of their thought processes. Whilst the successes were acknowledged, the trainees also considered the challenges associated with enabling progression in science learning.

11.1.1 Evidence of higher order thinking skills

Having access to outdoor opportunities and natural resources can support and extend learning, which may be more challenging to facilitate when learning about science indoors (Kim *et al*. 2020). The outdoors is unique in providing the opportunities for critical incidents (Serret *et al.* 2017) to occur within science due to the freedom and purpose that it provides. These significant moments enabled the children to develop their higher order thinking skills.

The following three examples are evidence of higher order thinking skills being achieved in an outdoor context. The judgments on quality of learning by the researcher, in terms of thinking scientifically, were possible because of the trainees’ assessment of the learning. This was made possible through meeting the relevant success criteria on the matrix and by the level of support and abstraction that was appropriate for the age of the children.

In the first example the children, age 5-6, were using what they had found out in the previous session 'to help them to find out new things'. They were 'surveying' the feeding habits of worms in the outdoors. As reported by TR1:

> *"Doing the food chambers, they knew worms were in soil, so they knew that they would obviously be attracted to that but then they wanted to find out new things as to whether they might prefer other food in different food chambers" (TR1 44:24).* This demonstrates **application** in ideas, problems and questions in relation to the criteria on the matrix.

The second example shows how the learning was led by the children and how the outdoor context provided opportunities for first-hand experiences that enabled them to demonstrate ideas and problem solving skills. This was an example of children in the second school using 'what they already knew to explain new things' and applying ideas based on the water cycle to describe simple processes or phenomena. As reported by TR2:

> *"We did the sensory hunt, there are a lot of puddles and somebody asked how do puddles disappear [misconception acknowledged], so somebody else was explaining that the sun evaporates it [misconception acknowledged] … so I said what would happen to the puddle if the weather became minus 1 degrees, so I just thought I'd see if they could answer that and they were able to say that it would freeze, and it would turn into ice, because the particles change state" (TR2 37:06).* This demonstrates **synthesis** in ideas and problems in relation to the criteria on the matrix.

The third example shows how the children in the second school named the parts of the plant and went on to apply this knowledge in order to understand the reproduction of the plant. They experienced, recognised and named things in the natural world. The children's understanding progressed from being able 'to name' to being able 'to explain ideas, processes and phenomena'. As TR2 reported:

> *"…just recognising the basic features… I think as far as we got with plants was that they have petals whereas now they would be able to say about fungi, they would be able to list different types of plants, they would be able to explain how plants grow, the life cycle, so they've got a lot more information. So even saying leaves and roots, they could explain how they absorbed water and nutrients… which they could never have done at the start. It wasn't as if I just spent the*

> *whole lesson just feeding them information either" (TR2 42:49).* This demonstrates **synthesis** in ideas and **analysis** in problems in relation to the criteria on the matrix.

The outdoor examples illustrate the children's ability to demonstrate higher order science skills where the children were thinking about science beyond National Curriculum (GB.DfE 2013) expectations and therefore displaying a high level of abstraction for their age. One example was in relation to environmental disasters such as wildfires in Australia (TR2 38:30) when explaining drought. The summary (Appendix 17) is a sample of researcher analysis which shows further specific outdoor examples and how they link to the matrix. When reviewing the evidence, the majority of the links were made by myself, however the trainees were able to demonstrate some connections through their interview discussion when making sense of the learning. This involved being able to recognise specific examples of higher order thinking. These included *application* through predictions about dormancy, plant growth and decomposition, as well as *synthesis* through explanations about life processes, changing state, the weather and forces.

These examples show the variety of thinking scientifically skills that were adopted as part of the outside learning provision, where outdoor learning goes beyond exploration and social values (Eaton 2000). These unique examples, which demonstrate the potential for achievement for a wide range of primary aged children, can be interpreted through multiple perspectives and also be aligned with more than one success criteria from the matrix. Within 'ideas' these may be most closely aligned with synthesis and evaluation but within 'problems' this links more closely to analysis, resulting in a best fit approach being taken.

11.1.2 Progressing in scientific thinking

Some of the 'primary science' indicators of progression identified by Harlen *et al*. (2003) were used by the researcher in this study to enable trainees to understand progress in scientific thinking. Those most relevant to learning in the outdoors were raising questions, gathering evidence by observation and measurement, communicating and reflecting critically, as well as drawing conclusions. These were then considered together with the criteria from Ward and Roden (2016) and incorporated into the matrix design (section 8.1.2). Evidencing progression in 'thinking scientifically' has been underdiscussed in the literature (Harrison and Howard 2010; Nuffield Foundation 2012) and there was no statutory guidance to support the trainees' practice. As a result, they employed the matrix to scaffold their judgements. Progress in outdoor science was identified by the trainees through the children's ideas (TR3 26:06), problems (TR2 38:30), evidence (TR1 51:17) and questions (TR1 21:17, TR2 3:50) which relate to the thinking scientifically success criteria on the matrix.

The trainees were able to exemplify the learning, by evidencing progress from knowledge to the higher order skills of synthesis and evaluation. This was made possible by assigning the learning to the progressive criteria in the matrix. The examples of learning were shared by the trainees during the interviews and were supported by the observations and documentary analysis. I assigned the criteria from the matrix to support the connections that they had identified. Figure 18 includes illustrative examples of where the children demonstrated knowledge of ideas, problems, evidence and questions linked to the matrix. The examples were linked to the thinking scientifically criteria that were met within the categories from Bloom's taxonomy (Bloom *et al*. 1956).

Categories from Bloom's taxonomy (Bloom *et al*. 1956)	'Thinking scientifically' success criteria	Examples from children's learning.
Knowledge:	Identification and recognising features Curiosity	*Drawing mini-beasts and sorting them according to their features (TR3 06:37).* *When there is a purpose, they really want to know, raise questions, discuss, observe and have a go themselves (TR1 25:55) demonstrating ownership, independence and engagement. A sensory hunt involving physical touch and observation created more questions and greater curiosity (TR2 03:50).*
Compre-hension:	Comparing, including identify differences,	*They compared and ordered photos and drawings focusing on their observations of the lifecycle of the daffodil (TR3 23:18). Physically picking up a holly leaf, comparing it with a sycamore leaf and using an identification card to classify it in relation to the "spiky"*

	similarities or changes	*features (TR2 09:29). Being able to explain the differences between fungi and plants (TR2 30:45) and colour change in dying and decaying matter (TR2 23:25).*
	Sorting, grouping and classifying	*Classifying plants including ferns, mosses and trees, and explaining choices using a classification key (TR2 08:11, 32:01).*
	Measuring	*Time taken for the banana peel to decompose (TR3 37:40). Counting the number of minibeasts that chose a certain environment within a choice chamber within a day and a week (TR1 51:17).*
Application:	Connections and matching	*Running made her heart pump fast and she was using up oxygen resulting in her being out of breath (TR2 37:31).*
	Predicting	*One child predicted that there would be more ants than worms and disproved this through counting their occurrences (TR3 08:11).*
	Suggest improvements	*With the children taking on greater ownership, they were discovering things rather than being taught things (TR3 01:10), finding their own answers (TR3 51:00). They were trying to improve what they had already done by raising measurable and investigable questions to further their understanding (TR1 1:10:36). They were thinking about what was working and what was not working (TR1 28:49).*
Analysis:	Explaining	*They were recognising basic features of minibeasts such as number of legs, antenna, wings. This moved to reasoning, for example exploring whether it was a fly because it had wings and whether it had a skeleton for it to be a vertebrate (TR3 40:32).*
	Cause and effect	*One recognised a plant was dying because of the seasonal changes and they needed sunlight to grow (TR2 11:42).*
	Using prior knowledge or experience	*They noticed relationships between living things in their environment through using pre-existing knowledge and findings focusing on their experiences of Daddy-longlegs and the season, including their*

		experiences of counting insects during play time on the field (TR3 22:10). Comparing decomposing banana peel with their experiences of mouldy bread at home (TR3 26:06).
Synthesis:	Decision making and problem solving	*They were designing child-led enquiries deciding on their independent and depended variables (TR3 47:07) including designing bug hotels (TR1 42:57). This linked to reasoning when discussing the location of the bug hotel in light of predators, access including for flying insects, breathability and appropriate material choices (TR2 1:00:39).*
Evaluation:	Explain how new scientific evidence is interpreted by the scientific community.	*They were comparing results within the group and appreciating the reliability of the data. They were considering more than just their own experiences (TR3 42:48) and not relying on being told an answer or accepting a result. They were drawing on a range of findings and were considering the number of people who got the same result (TR3 43:36). They also showed an appreciation for the importance of evidence for the scientific community in relation to their explanations about Coronavirus (TR2 24:25).*
	Use abstract ideas linked to the plant life cycle	*Taking their own experiences of things like the first frost and relating it to dormancy in the plant life cycle (TR3 44:11).*

Figure 18: This shows the progression within the examples from knowledge to evaluation based on Bloom's taxonomy (Bloom *et al*. 1956).

The trainees collected and made sense of the learning. I was able to analyse the evidence that was shared by the trainees. It involved a joint understanding of the learning and the use of the matrix enabled us to identify the children's achievements. The evidence, linked to the matrix, shows that the children achieved a variety of thinking scientifically success criteria.

The examples of learning highlight the quality of outdoor science learning that was occurring. Within the categories from Bloom's taxonomy (Bloom *et al*. 1956), the simple ideas become more complex, as did the quality of reflection. Aligning the examples with the criteria provides a gauge for assessing the learning and identifying the next steps.

The trainees used the matrix to help them to identify the next steps in learning for the children and what they intended to action in order to plan for progression. These included:

- Evaluation, in particular, time for discussion and debate enabled by stronger communication with an emphasis on vocabulary (TR1 28:49).
- Using scientific evidence (TR2 46:25).
- Reflection and self-evaluation (TR2 1:05:14).
- Reflection and vocabulary (TR2 49:05).
- Next steps focused on dealing with misconceptions (TR3 8:11)

These examples highlighted the need for greater opportunities for reflection and discussion within the learning. They demonstrated the need for the cognitive and metacognitive elements to be intrinsically linked and suggest that scientific thinking and progression can also be promoted through the role of reflection (Moon 2004).

Whilst the matrix provided the trainees with an initial scaffold for their judgements about the children's learning, additional considerations relating to progression were highlighted. The trainees identified evidence of learning which revealed significant progressive steps in the children's learning. These have been categorised in the following ways using four common concepts:

- Random and abstract ideas developed into more purposeful and complex thinking
- Single-step process developed into multi-step and investigation-led approach to the learning
- Exploration developed into consolidated learning and demonstrated application of knowledge
- A change from the children relying on the teacher, to the children taking ownership of the next learning steps

The following examples are evidence of learning that has been categorised using these concepts. Firstly, questions moved from "*Why do snails have shells?*" and "*How is bark made?*" to those based on what the children had experienced, for example "*Can we speed up the growth of the daffodil by putting it in the freezer?*" (TR3 52:38). This shows the random and abstract developing into more purposeful thinking (TR3 54:18, TR2 37:31).

Secondly, at the beginning of the series of learning opportunities, the trainees found that children were not remembering what they had learnt and they did not revisit their learning or their questions. This progressed to them being able to describe what they saw and what they did, for example when they were learning about bird's nests through sorting and grouping. The evidence showed that this single-step process developed into a multi-step and investigation-led approach to the learning which showed deeper reasoning with more investigable questions. The children knew what they were doing and what they were investigating when looking at micro habitats, for example when designing their bug hotel (TR1 36:07).

Thirdly, children's exploration developed into consolidated learning and demonstrated application of knowledge. The trainees showed that opportunities for revisiting learning about worms related prior knowledge to habitats (TR1 19:19). One child asked, "*Why do we have daffodils in spring?"* so the child already knew the season when daffodils grew but didn't know why that might be the case (TR3 6:02). Another child linked their experience of planting bulbs with a grandparent in her garden (TR3 25:07) including positioning and varying temperature to speed up growth (TR1 5:00, 9:21, TR3 54:18).

Finally, there was a change from teacher-led learning to children taking ownership of the next steps. The examples of using pooters to collect the minibeasts for closer observation and asking more measurable investigable questions (TR1 1:10:36), showed greater independence and ownership of their learning (TR1 06:01, TR3 15:28). They were able to express themselves and raise further questions with a desire to find out more (TR1 06:01, 1:10:36, TR3 37:40) and sustain curiosity over time through the development of scientific attitudes.

Within these examples, the trainees found that children were not only able to show that they could utilise higher order thinking skills, such as application and synthesis (Bloom *et al*. 1956), but also demonstrate their ability to think scientifically and further their scientific literacy (Scott and Boyd 2014; Wilson and Holligan 2018). This correlates with the attainment findings from Hanley, Slavin and Elliott (2015) who found that, within primary science practice, the impact of embedding thinking into their intervention schools was equal to an extra three month's progress over a year.

Trainees found that self-efficacy was demonstrated more over time. The examples showed that children understood the expectations for the learning and were able to value their own questions. This is shown in the example from TR2 who showed that children were:

> *"Raising questions about the world around them, drawing on their experiences, questioning why things happened… so rather than just asking a question, they wanted to know more about the question… rather than just asking what something is and being stimulated by exploration." (TR2 42:18).* This demonstrates **analysis** in questions in relation to the criteria on the matrix.

With the child's ideas at the centre of learning, self-efficacy and ownership were seen through these examples (Harlen 2018). This is supported by the findings of the Education Endowment Foundation (EEF) which value metacognition in enabling progression (Quigley, Muija and Stringer 2018). The examples also highlight how the outdoors provided authentic opportunities to develop metacognition.

11.1.3 The place of metacognition within thinking scientifically

Metacognition is a key element of thinking scientifically where children were conscious of their own thinking and the problem solving process (Adey and Serret 2010). The evidence suggested that metacognition was found to be associated with 'learning to learn'. It was highlighted in the examples from the interviews with the trainees. In the first example, the children were taking ownership of their learning, behaviour and questioning, as demonstrated by TR1:

> *"Deepening their questioning skills for them to actually secure that reasoning,…. they actually know what they are doing, what they are investigating and why" (TR1 37:54).* This demonstrates **analysis** in questions in relation to the criteria on the matrix.

In the second example, TR3 stated that one child managed their own learning through the identification and accommodation of new learning (Piaget 1978) as a result of an initial misconception:

> *"When we were planting the trees… and one of the children said how does a tree fit in a bean, erm, seed, I said to the child after we had done the enquiry 'oh so*

> *how do you think the tree does fit in the seed then?' and she was like 'well it doesn't fit in there, it grows' so she'd addressed that misconception herself" (TR3 32:11).* This demonstrates **application** in ideas and evidence in relation to the criteria on the matrix.

These two examples were associated with the higher order thinking skills criteria on the matrix. They also demonstrated metacognition when the children took ownership of their learning.

Trainee TR1 (TR1 1:10:36) reported that the children could 'suggest improvements and raise further questions' and that the children were trying to improve what they had done in order to further their understanding. In line with research from the Education Endowment Foundation, the children were able to put forward improvements to their work suggesting that metacognition and self-regulated learning was occurring (Quigley, Muija and Stringer 2018). It has been found that pupils make an average of seven months additional progress as a result of engaging with learning through metacognition and self-regulation (EEF 2021). Developing these metacognitive skills within science learning may enable them to apply them for a wide variety of purposes within their wider education (Zimmerman 2002).

According to TR1, the booklets were a tool that enabled the children to take ownership of their own learning, record their data, close the knowledge gap, document their learning journey and develop their confidence (TR1 14:42). This example shows how metacognition was identified as a result of post-learning reflections using the booklets:

> *"They showed me quite a lot about their knowledge that they had gained… they drew the lifecycle of a daffodil and then the beans that we'd planted. They took notice of the roots growing on the bulbs … so the booklets definitely showed me that the children were definitely taking on board the things that they had observed and that they had learnt through the sessions and they filled those out afterwards so it shows that they had kind of taken that in and retained it" (TR3 7:30).* This demonstrates **analysis** in ideas, **application** in evidence in relation to the criteria on the matrix.

Through the development of self-efficacy (Bandura 1977; Bandura 2001; Gutmas and Schoon 2013) or self-confidence in their own ability to be successful, the children can understand their next steps in learning and have greater opportunities to achieve analysis, synthesis and evaluative outcomes. This can be seen in an interview (TR2 47:05) where the focus was on the children understanding their next steps in learning required to achieve analysis. This included the need for time to reflect on the learning, for linking learning to current issues in society such as the global pandemic, for questioning the accuracy of evidence or for holding opinions about the evidence. According to TR2, they understood how their questions led to a line of enquiry and the next steps for their enquiries:

> *"In synthesis where it says 'ask questions and develop a line of enquiry based on observations', they asked the question… 'Why are the leaves changing colours?' so that did lead to a line of enquiry to find out about the life cycle of a plant" (TR2 52:44).* This demonstrates **synthesis** in questions in relation to the criteria on the matrix.

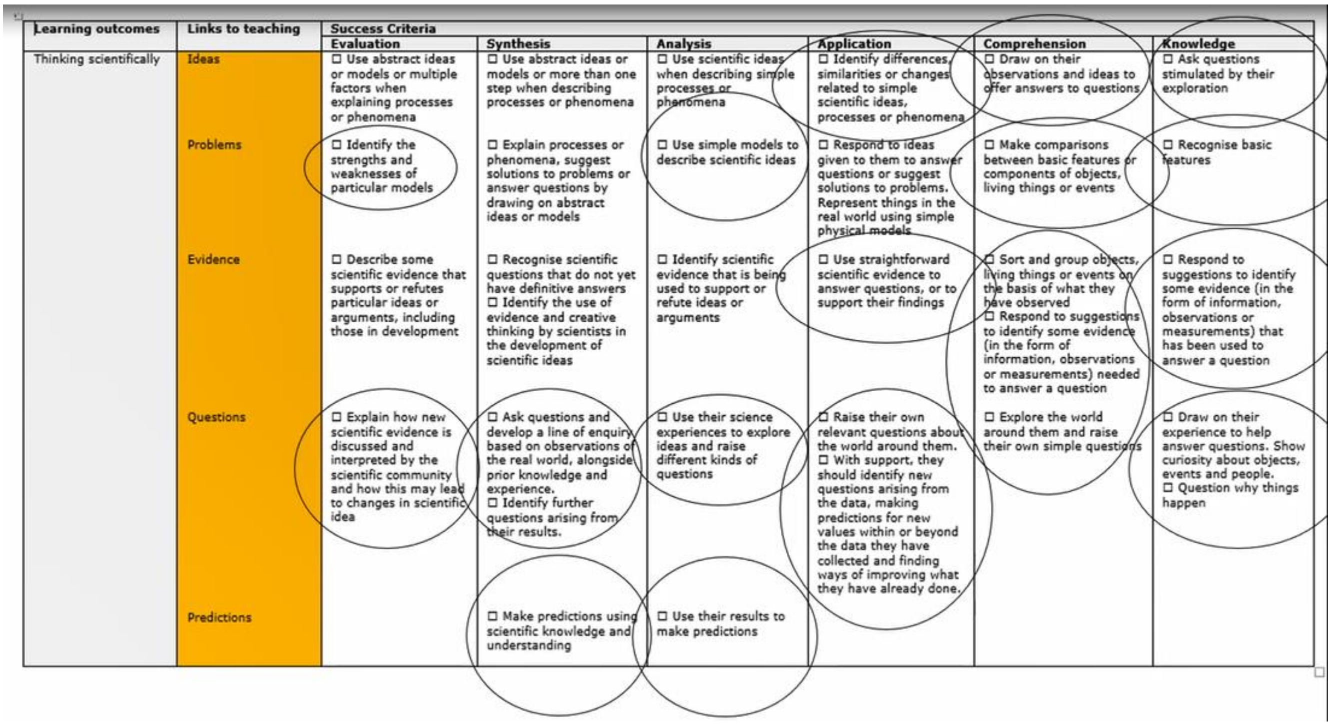
Questioning and success criteria were utilised to enable the children to understand the next steps and synthesis was achieved in relation to the work on the water cycle (TR2 50:10), Coronavirus research (TR2 39:34) and interpretation of evidence (TR3 42:48). This evidence supports the fact that metacognition enables teachers to support the learning of children by empowering the children and sharing the responsibility for the learning, whist maintaining high expectations (Loizou and Charalambous 2017).

11.1.4 The challenges associated with higher order success criteria

It was necessary for the trainees to manage the difficulties of mapping out the achievement and progression of children's scientific learning in the outdoors. These included:

- evidencing higher order success in the learning
- engaging with scientific evidence
- using abstract ideas
- vocabulary choices
- secondary sources
- responding to need 'in-the-moment'

The trainees found it challenging to identify evidence of learning that met the *higher order success criteria* within the matrix. This included examples of analysis, synthesis and evaluation, for example identifying evidence and abstract ideas. TR3 identified the criteria that had been achieved within the learning for the group of children within one case study. Figure 19 highlights the children's reliance on knowledge and the success in their ability to achieve the evaluation criteria.



Learning outcomes	Links to teaching	Success Criteria					
		Evaluation	Synthesis	Analysis	Application	Comprehension	Knowledge
Thinking scientifically	Ideas	☐ Use abstract ideas or models or multiple factors when explaining processes or phenomena	☐ Use abstract ideas or models or more than one step when describing processes or phenomena	☐ Use scientific ideas when describing simple processes or phenomena	☐ Identify differences, similarities or changes related to simple scientific ideas, processes or phenomena	☐ Draw on their observations and ideas to offer answers to questions	☐ Ask questions stimulated by their exploration
	Problems	☐ Identify the strengths and weaknesses of particular models	☐ Explain processes or phenomena, suggest solutions to problems or answer questions by drawing on abstract ideas or models	☐ Use simple models to describe scientific ideas	☐ Respond to ideas given to them to answer questions or suggest solutions to problems. Represent things in the real world using simple physical models	☐ Make comparisons between basic features or components of objects, living things or events	☐ Recognise basic features
	Evidence	☐ Describe some scientific evidence that supports or refutes particular ideas or arguments, including those in development	☐ Recognise scientific questions that do not yet have definitive answers ☐ Identify the use of evidence and creative thinking by scientists in the development of scientific ideas	☐ Identify scientific evidence that is being used to support or refute ideas or arguments	☐ Use straightforward scientific evidence to answer questions, or to support their findings	☐ Sort and group objects, living things or events on the basis of what they have observed ☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) needed to answer a question	☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) that has been used to answer a question
	Questions	☐ Explain how new scientific evidence is discussed and interpreted by the scientific community and how this may lead to changes in scientific idea	☐ Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience. ☐ Identify further questions arising from their results.	☐ Use their science experiences to explore ideas and raise different kinds of questions	☐ Raise their own relevant questions about the world around them. ☐ With support, they should identify new questions arising from the data, making predictions for new values within or beyond the data they have collected and finding ways of improving what they have already done.	☐ Explore the world around them and raise their own simple questions	☐ Draw on their experience to help answer questions. Show curiosity about objects, events and people. ☐ Question why things happen
	Predictions		☐ Make predictions using scientific knowledge and understanding	☐ Use their results to make predictions			

Figure 19: This figure represents the achievement of the children working with TR3 over the series of learning opportunities within one case study. The circles show the strengths and the non-circled text shows the attainment gaps in the learning.

At the end of the series of lessons, the matrix was completed by TR3 (Figure 19) for the group of learners in the case study. It suggests that there were fewer examples of learning linked to the 'evidence' and 'ideas' elements of thinking scientifically. The trainee recognised the successes and reflected upon the gaps.

Providing outdoor opportunities for children to *engage with scientific evidence,* for example using evidence to support or refute ideas, rather than relying on exploration and observation, may help the children to achieve the higher-order skills. Using the matrix as a guide, the following example shows that the next learning steps were considered and there was an awareness of the challenges of assessing evaluation practically, "*Going into that evaluation side. Being able to do that, how can I support children to 'explain how new scientific evidence is discussed', but how can I push* *them?*" (TR1 53:47). The trainee was unsure about how to challenge the children appropriately or how to enable them to explain new scientific evidence.

The diagram (Figure 19) also shows the lack of examples that demonstrate the use of *abstract* ideas within the synthesis and evaluation criteria on the matrix. Defining abstract and ensuring the trainees understand the criteria in order to achieve this consistently is challenging. One example of this is where one trainee acknowledged the higher-order learning example. "*We were learning how to make a birds nest, to lay their eggs*" (TR1 9:50). They were using scientific language and were able to evaluate and reflect on that discussion. "*They explored why they used different twigs, reasoning about the different types of birds, beaks and different trees etc. and how they hold it together*" (TR1 10:52). The trainee decided that the lifecycle of the bird met the expectations relating to 'explain abstract ideas' and explanations and argumentation linked to animal behaviour and habitats, providing evidence to 'support or refute ideas or arguments'.

This was judged by the trainee to be evidence of 'evaluation' however it could be viewed as closely aligning with 'analysis', therefore it highlights the challenge of the interpretation of evidence in support of the attainment of evaluation. When considering the judgement of age and ability, the learning for these children was deemed to be exceeding expectations. However, the higher-order criteria for evaluation goes beyond the 'process' of evaluation and reflection, such as "*making connections to possible next steps in order to solve the problem*" (TR3 44:11), to include 'evaluative thinking'. It is necessary to consider if the evaluation criteria are attainable for all ages and how 'abstract' might be viewed differently according to the age and ability of the child (Vigliocco, Ponari and Norbury 2018). It is also important to contemplate how the 'science community' was viewed as well as the interpretation of 'multiple factors' and 'ideas in development' when looking at strengths and weaknesses of models and processes and phenomena. These are elements that need to be considered in the refined matrix. Therefore, it is necessary to ensure the models, factors, processes and phenomena are age appropriate. In line with the National Curriculum programme of study (GB.DfE 2013), there needs to be clarity in our science guidance for trainees, and for teachers more generally, in terms of what is deemed to be abstract for five-year-olds and whether this is the same for eleven-year-olds. There also needs to be clarity in the expectations of vocabulary to enable children to achieve the abstract criteria and to successfully explain their ideas.

There was a similar challenge in assessing the higher-order science skills when considering the children's age-appropriate *vocabulary choices*. The vocabulary choices for the children age 5-6 were seen to be less advanced than their practical skills. Going forward, it would be interesting to find out more about the potential for children of a younger age to achieve the higher order success criteria and what adaptations would be necessary. TR1 effectively referred to this by stating that, "*The issues they have are related to vocabulary*" (TR1 31.00). "*They haven't used that much scientific vocabulary for their…. age, but in some sense they are showing that they are thinking scientifically and they are raising… an enquiry from what they have found*" (TR1 45.23). This highlighted the challenges in assessing their outdoor science vocabulary which may have limited their attainment, compared to the demonstration of their practical and scientific thinking skills. This supports the point made by Ofsted (2021) that practical learning is dependent on the children's grasp of scientific vocabulary, which will aid both retention and recall of knowledge. Through working practically, and the use of disciplinary literacy, new knowledge gets systematically integrated into pre-existing knowledge, which in turn allow children to operate at more abstract levels (Bernstein 1999; Ofsted 2021).

The *use of secondary sources* was seen as another challenge. Whilst the use of secondary sources is a requirement in the National Curriculum (GB.DfE 2013) and features in the non-statutory guidance (GB.DfE 2013), none of the trainees mentioned this in terms of a success in the learning but some trainees commented on the value of pre-learning (TR3 48:17). When reflecting on the use of secondary sources TR3 suggested that "*It might have helped if they were in the classroom and they could have read books or they could have used the internet to find out what's already known before actually planning their enquiry"* (TR3 49:25). This suggests that working indoors can support outdoor science as both were valued in relation to the use of secondary sources.

TR3 emphasised the challenge of planning for the use of secondary sources within child-led learning and that it was "*Impossible to know what kind of things that they may struggle with*" (TR3 33:40). This shows the potential limitations associated with the trainee's stage of development and experience. However, one trainee commented that secondary sources could be used to follow up on an area of interest or conflict which has been initiated by the learning (TR3 50:31) and at a point when the child is at 'flood readiness' (Brierley 1994; Fisher 2013). Research has shown that secondary sources can be used outdoors to respond to the ‘in-the-moment’ needs of the child through the use of digital technology (Kacoroski, Liddicoat and Kerlin 2016; Stagg, Dillon and Maddison 2022). This was relevant for TR1 who stated that the children had a gap in their knowledge in relation to birds nests which limited their attainment (TR1 14:42), however in this situation, the use of secondary sources, such as iPads, had the potential to support the children with their subject knowledge development and give them the skills to apply their knowledge practically in the outdoors. This would require a fine balance between child and teacher-led learning but could enable the children to see the connections between the ‘knowledge’ and ‘skills’ whilst still maintaining a child-led approach.

11.1.5 Summary and contribution to knowledge

Within this section, the data highlights several key points which demonstrate that outdoor learning supports thinking scientifically, through highlighting:

- the importance of knowledge and how this underpins the learning,
- the exemplification of higher order thinking skills,
- the use of a range outdoor specific approaches to learning such as: experiential learning, surveying, using prior learning to find out and explain new things as well as describing and applying understanding to scientific processes and phenomena,
- the progression in outdoor science which was demonstrated through the use of four common concepts including a shift from: random and abstract *to* more purposeful and complex ideas, single *to* multi-step processes, exploration *to* consolidated learning and application of knowledge, relying on the teacher *to* children having ownership of their learning and next steps,
- the next steps required for the learning to improve further within all case-studies include: using scientific evidence, reflection and self-evaluation, vocabulary and dealing with misconceptions,
- that metacognition was evident when the children were achieving higher order thinking skills, had ownership of their learning and could self-regulate, which in turn had an impact on their progress and self-confidence.
- the future adaptations ‘to’ and exemplification ‘of’ the matrix should be taken into consideration including: evidence of learning in-the-moment, using scientific

evidence outdoors and incorporating secondary sources, understanding age related vocabulary choices and age-appropriate abstract processes and phenomena.

The matrix provides a concrete structure that supports trainee teachers in developing their assessment practice of and pedagogy in the abstract concept of ‘thinking scientifically’. The trainee teachers have been able use this to develop a concrete understanding of assessment of learning within outdoor science. It enabled the learning in the outdoors to be captured and analysed. The exemplification of the learning provided reliability in the success criteria and demonstrated the potential for achievement within learning including higher order thinking skills. The key points will provide a basis from which to enable trainee teachers to effectively support the children’s learning in primary science, using the outdoors.

11.2 Chapter 2: ‘Behaving scientifically’ in the outdoors

Behaving scientifically can be understood as something that goes beyond completing experiments and finding results, as defined by Venables and Tan (2006).

It includes actions such as:

- observing over time,
- identifying and classifying,
- problem solving,
- articulating their scientific behaviours.

It also encompasses decision making, the ability to take risks and the use of trial and error. The data analysis documented a range of children’s behavioural approaches to science and showed how the children’s scientific attitudes, in particular curiosity, developed.

11.2.1 Evidence of children’s scientific behaviour

When capturing the learning associated with behaving scientifically, much of the evidence was collected through formative assessment, including recording practical learning that was demonstrated through a sensory, hands-on approach that aligns with experiential, child-led learning. This was also commented on by TR2, who stated that, “*When it was sensory and child-led, they had a bit more freedom and they tended to ask more questions*” (TR2 27:02). The motivational behaviour associated with outdoor learning was also highlighted as being more than just a novelty factor (Hoath and Spring 2018). It provided the impetus for the learning for example “*Planning from their questions, if they wanted to go and look at something then they could investigate it, they could get a closer look*” (TR2 1:12:34) and “*Just getting a lot more from them in terms of understanding, participation, being willing to talk, being willing to ask questions, I don't think I would have got as many questions in the classroom*” (TR2 1:13:02). The trainees showed that working outdoors was less rigid and suggested that children felt like it was a safer place to question due to being less confined and more relaxed. TR2 included their opinion by comparing the learning with their indoor experiences. This is supported by Dowdell, Gray and Malone (2011) who found that children’s behaviour was affected due to being less inhibited in use of language outdoors and resulted in them making five times as many utterances outdoors as they do inside.

There was evidence of the children behaving scientifically. This was demonstrated through their abilities to take risks (TR3 08:11) and use trial and error in their approach to science learning (TR3 42:48). In the following example, the children working with TR1 wanted to *observe over time* so they were raising questions and they were thinking more deeply about what they had found and observed in the outdoors:

> “They were able to go on to design their bug hotel and think ok, so I have found out this, I have found out where worms live, but then I want to find out… Why do they live there? What do they get from the soil?” (TR1 22:34) … for example “‘How could I design a new home for a worm?’, ‘How can I see which one it prefers?’, so having three different homes for it, they were then able to investigate that and see and then over time they could then be able to record that data” (TR1 40:16). This demonstrates **analysis** in ideas, **application** in problems and **synthesis** in questions in relation to the criteria on the matrix.

The example above shows an awareness of scientific ideas when exploring the problem. It ‘uses scientific ideas’ associated with habitats and feeling patterns, ‘suggests solutions to problems’ and ‘develops a line of enquiry based on observations’ in the real world. It also shows the children’s ability to question and develop a line of enquiry based on observations of the real world.

The next example shows that children were behaving scientifically as a result of *identifying and classifying*, as reported by TR1:

> *“We did classifying mini beasts and in their drawings a lot of them were quite accurate to the features that the classification cards tried to get them to notice (TR1 06:37). None of the children could actually identify it. But when they had the classification cards they were able to look at the features of the earwig and then classify it and then record their results. They actually spoke about that in their evaluation of their enquiry” (TR1 12:06).* This demonstrates **application** in ideas and evidence in relation to the criteria on the matrix.

It shows that the children were able to identify the mini beast using differences and similarities through classification. They were using observational evidence to support their findings.

In the following example, the children working with TR3 were demonstrating their *problem solving* skills through collaboration. It shows the scientific approaches to problem solving, which included using prior knowledge, clarification, accuracy, trial and error, comparing and contrasting their results:

> *They were all giving their opinion of what they thought it was and then one of the boys was comparing it to something that he had seen in a film or something. That's when I gave them the classification cards… one of them counted the legs and the other one was like 'no, no that's not right, we need to count it again'. (TR3 14:47). So that actually encouraged the group work and the problem solving between them. Two of them said 'I'll do it and then you can do it at the same time and we'll see if we get the same answer' (TR3 15:11). They obviously thought that the more people that think that there is more chance of it being that…they were doing it independently and then coming together to compare their results (TR3 15:28).* This demonstrates **application** in ideas, **application** in problems and **analysis** in evidence in relation to the criteria on the matrix.

The example above shows how the children were noticing differences in their observations. They were responding to one another when looking for a solution and using their prior knowledge to support their explanations. This evidence of decision making shows a high level of self-efficacy.

In relation to problem solving, decision making also encourages "guess work, inspiration, correction, blind alleys, hypothesis testing, dead ends and backtracking" (Venables and Tan 2006 p123), as well as risk taking and learning from mistakes (Ward and Roden 2016). This was seen when looking at seeds (TR3 32:11) when a child addressed her own misconception as a result of the enquiry that the children had undertaken.

The following example of self-efficacy was supported through the child's reasoning which enabled them to find a solution through their findings in the real world. The children working with TR2 learnt how to *articulate the scientific behaviours* that they were undertaking:

> *"So asking at the end of a session, 'what did they think they had done today that scientists do?'. … they would be able to explain, whereas I don't think they'd ever had that before, … where they know that they are predicting, they know that they are collecting data, they know that they are analysing the evidence and evaluating (TR2 1:05:14).* This demonstrates **synthesis** in problems and **synthesis** in evidence on the matrix.

The previous example shows how the children were able to explore their ideas based on their findings and think like scientists to develop scientific ideas. They were able to use enquiry skills to find solutions to problems. TR1 found similar evidence and also demonstrated the enthusiasm of two children: "*I like learning where you can investigate, means finding things out in different ways*" and "*you feel like a detective, say if you want to investigate you have to take risks*." (Appendix 18a). This was further evidence of self-efficacy and showed that taking risk and decision-making are seen to be valuable behaviours needed to work scientifically.

Working in the outdoors provided a wealth of evidence showing children's scientific behaviours. They demonstrated the scientific thinking skills, application, analysis and synthesis through their ability to observe, identify and classify. The children's self-efficacy enabled them to take risks using trial and error approaches to problem solving within an environment that was less rigid than an indoor classroom. The application of the matrix was central to the trainees being able to identify these traits. The children's ability to regulate their own learning, through their articulation of and reasoning about their scientific behaviours, supported their scientific literacy and will help to provide them with a set of life skills for thinking rigorously about problems and issues both educationally and in society.

11.2.2 Attitudes identified when behaving scientifically

In the outdoor context of this study, a number of scientific behaviours were highlighted within the evidence of learning, which incorporated the development of attitudes and generating questions through curiosity. Attitudes to learning were commented upon by all three trainees and were demonstrated by the children when they were behaving scientifically in the outdoors. The examples from the interviews suggest there are a combination of factors that work holistically to contribute towards the child's attitudes (McCrory 2018). These ranged from:

- cognitive scientific attitudes such as: curiosity, creativity, inquisitiveness, imagination, critical mindedness, respect for evidence, honesty, objectivity and open-mindedness.
- affective attitudes towards science such as: motivation, engagement, commitment to science learning, resilience to setbacks and taking pride in achievements.
- ethical nature friendly attitudes such as: respect, perusing coexistence with nature, love and affection towards living things, empathy for creatures, sense of oneness and a sense of responsibility, preference toward the natural environment and nature conservation.

Attitudes encompass so many different dimensions (Harlen and Qualter 2018) and the authentic learning opportunities from the outdoors enabled attitudes to be noticed in practice. The following examples highlight the importance of attitudes within children's learning and scientific behaviours. They show how the outdoor context was pivotal in the learning that was captured.

The first one shows the child's '*cognitive attitude'* of curiosity, an inquisitive approach and their ownership of the learning:

> *"Children have a lot of curiosity and want to know why and how things work and what's happening. So kind of inspiring that by taking them outside and then them being able to plan and design their own enquiries is definitely something that I think is important." (TR3 1:03:16).* This demonstrates **knowledge** in questions in relation to the criteria on the matrix.

This focuses on attitudes in a holistic way by enabling the child's interest to lead the learning through a personalised approach. It goes beyond curiosity and shows how the trainee used the children's attitudes towards their enquiries to improve their ability to behave scientifically and influence their next learning steps. Lieberman and Hoody (1998) state that this approach to attitudes promotes self-esteem as a result of taking ownership of and responsibility for their own learning.

The second one shows a creative attitude to learning:

> *“It brings out that imagination and curiosity. Even just changing their attitude and motivation I think can make a massive difference. Supporting multiple needs so obviously it's very sensory, hands on, it can be teamwork or independent.” (TR2 1:11:59).* This is most closely linked to **knowledge** in ideas in relation to the criteria on the matrix.

Creativity is not something that is commonly associated with science but this supports the points made by Bianchi and Feasey (2011) about the importance of having the desire to find out, have ownership and be creative in science. It was also commented on by Collins (2015) and Kim *et al.* (2020) who value the use of imagination and senses in order to be open to new ideas and be creative. These contribute to their toolbox of scientific attributes and influence their ‘Science Capital’ (Archer *et al.* 2015).

The third example shows how the outdoor context provided the opportunity for the initiation of a desire to find out more, demonstrating the relevance to their future learning, as this example of curiosity and persistence shows:

> *“They were showing curiosity about it, about the objects and they were beginning to question why things happen and they were able to observe over time.” (TR1 25:00).* This demonstrates **comprehension** in ideas, problems and questions in relation to the criteria on the matrix.

This example shows how the children’s attitude influenced their desire to develop their scientific behaviours over time. The connection between learning over time and children’s attitudes was commented upon by Dillon *et al*. (2005). Smith (2016) also emphasised the importance of sustaining curiosity over time. This highlights the value of learning in the outdoors and the possibilities within longitudinal studies.

A common link between all three of the examples suggests that the trainees were more confident in identifying curiosity in the children’s learning than recognising the breadth of attitudes that could have been acknowledged within their ‘*cognitive attitude’* examples. They relied on the term curiosity when there was much more to appreciate, but with a clearer structure from the matrix, attitudes could have been more explicit within the expectations and assessment of the learning. Learning attitudes were not included in the higher order success criteria on the matrix but with better signposting, they could lead to improved learning outcomes, resulting in improved scientific behaviours. For example, attitudes such as initiative (Kim *et al.* 2020), critical mindedness, respect for evidence and nature, honesty, objectivity and open-mindedness could have been recognised (Harlen and Qualter 2018; Jenkins 2006).

The following examples demonstrate '*affective attitudes'* towards learning. There was evidence that the attitudes to learning were directly impacted by nature. Trainee TR2 stated that making scientific enquiry skills authentic supported a change in children's cognitive scientific attitudes (Appendix 18b), for example inquisitiveness. TR2 suggested that utilising science enquiry skills and finding 'real-life' examples of science enabled children to build positive affective attitudes towards science education as they understood its purpose and importance ethically, for example empathy.

When exploring children's attitudes towards outdoor science learning, trainee TR1 noticed that "*the freedom of the task allowed children the confidence to explore the nature garden"* which was seen to "*support their engagement in the learning*" (Appendix 18c). Further results (Appendix 18a) showed that the children's attitudes were positive, "*children's body language suggested they were comfortable and enjoyed the learning environment. They were interested in finding resources to add to their journey stick*[7]". This shows a direct link to working outdoors through exploration and the freedom of choice which are seen as valuable (Dillon *et al.* 2005).

From a starting point where children demonstrated stereotypical perceptions of scientists and little skills awareness (Appendix 18d), TR2 suggested that the evidence revealed that, as a result of learning science outdoors, children's growing positive attitudes to learning science increased motivation (Appendix 18b).

TR2 also showed the '*ethical nature friendly attitudes'* when she noticed that one pupil cautiously moved leaves because there "*might be bugs*" and they "*did not want to kill them*" (Appendix 18d), indicating that they also have a greater appreciation for environments and the world, thereby highlighting the child's values about nature (Ratcliffe 2007). This supports the findings of Kim *et al.* (2020), who explored nature friendly attitudes which built upon 'scientific attitudes' to include respect, love and affection towards living things, and Cheng and Monroe (2012) who found that empathy for creatures, a sense of oneness and a sense of responsibility were developed through outdoor learning.

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[7] * A journey stick can be used to capture the journey a child takes in the outdoors. It involves a stick with string attached. The string is wound round natural items that are found along their walk. It provides the opportunity for the children to reflect on each item found, in this case through a scientific lens.

Nature friendly attitudes were also evident within this research when the children shared their opinions about outdoor learning. They said that they liked "*being with nature, being able to talk more, finding real things and connecting with the outdoor world*" (TR2 59:53). They were also considering the location of the bug hotel and ease of access for all mini beasts including flying insects. They had respect for their environment when considering the need for protection from predators, ensuring they could breathe and recreating their natural habitat (TR2 1:00:39). The children were excited about growing and caring for their plants. They valued the need to regularly look after them and appreciated the reward of growing with a purpose (TR3 1:01:51).

The outdoors provided opportunities for children to be immersed in science, behave scientifically and demonstrate all three of the identified types of attitudes. The trainees commented upon the children's curiosity and positivity together with their nature friendly attitudes. However, it became apparent that whilst they acknowledged the importance of attitudes in expressing the children's scientific behaviour, the trainees mainly focused on curiosity in their articulation of the examples. There was also a lack of reference to wider attitudes within the matrix which led to a limited range of scientific 'cognitive attitudes' being identified within the examples. This provides scope to develop the matrix further.

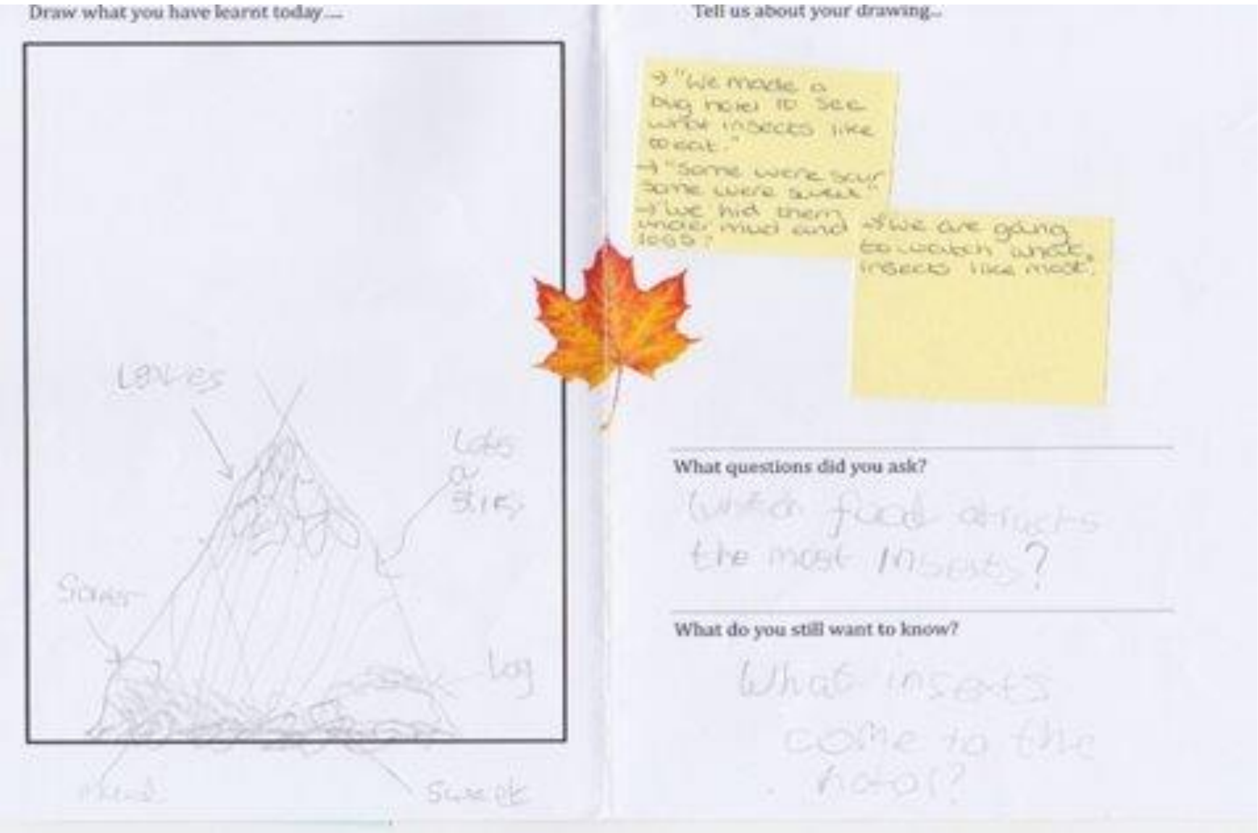
11.2.3 Curiosity generated questions

Curiosity was the main attitude that was reported on by the trainees when exploring the children's scientific behaviours. It encouraged the generation of questions when the children were immersed in the outdoors. Key aspects that influenced the type and quality of questions included:

- *Curiosity generated questions*
- *Number of questions*
- *Importance of stimuli*
- *Purpose of the questions*

Within the three interviews, curiosity was mentioned directly 19 times and demonstrated the children's motivation towards the activity. Trainee TR1 commented on the importance of curiosity in "*planning innovative strategies to ensure the children develop ownership of the learning to spark curiosity*" (Appendix 18e). She noticed that through their curiosity, the children showed a strong passion towards this learning which drew upon the outdoor context (Appendix 18f). Bianchi and Feasey (2011) support this through highlighting the positive benefits of outdoor learning for children.

Curiosity generated questions were mentioned in all trainee interviews. Although there was not a specific question focusing on curiosity posed during the interviews, the evidence for it emerged from the discussion. Trainee TR3 highlighted the link between curiosity and the skill of questioning (TR3 4:45, 39:58 and Figure 20a). She acknowledged the value of curiosity in authentic and engaging enquiries.



Draw what you have learnt today....

Tell us about your drawing..

→ "We made a bug hotel to see what insects like to eat."
→ "Some were sour some were sweet"
→ "We hid them under mud and logs"

→ "We are going to watch what insects like most."

What questions did you ask?

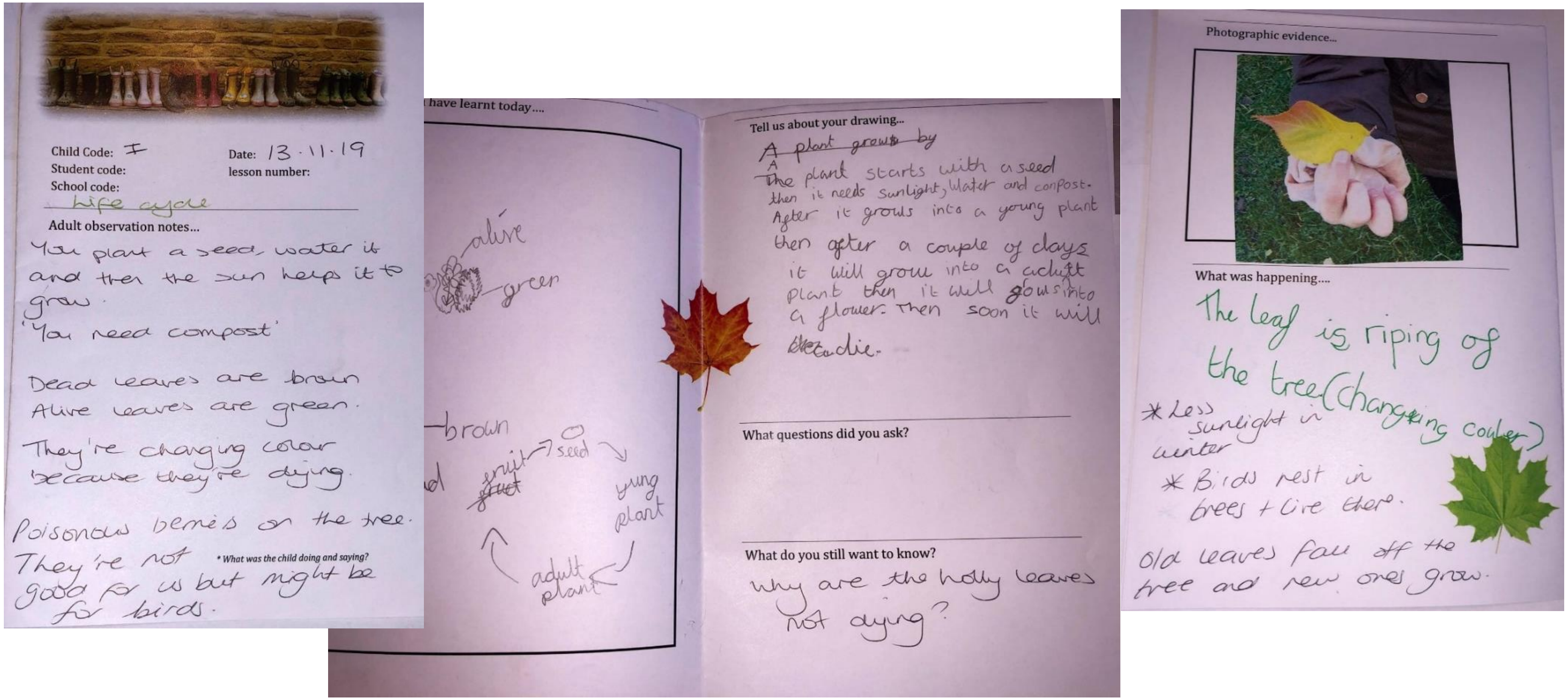
Which food attracts the most insects?

What do you still want to know?

What insects come to the hotel?

<u>Figure 20a</u>: This shows the curiosity generated questions asked by the 7-8 year olds working with TR3 (Appendix 18g).

Harlen and Qualter (2018) suggested that "*Children's questions that arise from curiosity and a desire to understand have a key part to play in learning science*" (p177). This was evident from the interview with TR1 (TR1 25:00, 19:30) where observations over time were identified as being important and were based on the simplicity of exploration through enabling them to "*Investigate mini beasts and* *different insects in their nature garden*" (TR1 19:30). This was also demonstrated in the field notes linked to decaying leaves (Figure 20b, Appendix 18h).



Child Code: I
Date: 13 · 11 · 19
Student code:
lesson number:
School code:
Life cycle

Adult observation notes...

You plant a seed, water it and then the sun helps it to grow.

'You need compost'

Dead leaves are brown
Alive leaves are green.

They're changing colour because they're dying.

Poisonous berries on the tree.
They're not good for us but might be for birds.

* What was the child doing and saying?

have learnt today....

Tell us about your drawing...

~~A plant grows by~~
A ~~The~~ plant starts with a seed then it needs sunlight, Water and conpost. Agter it grows into a young plant then after a couple of days it will grow into a adult plant then it will grows into a flower. Then soon it will ~~the to~~ die.

What questions did you ask?

What do you still want to know?

why are the holly leaves not dying?

Photographic evidence...

What was happening....

The leaf is riping of the tree (Changing couler)

* Less sunlight in winter

* Birds nest in trees + live there.

Old leaves fall off the tree and new ones grow.

Figure 20b: This shows how the 7-8 year olds working with TR3 were considering changes over time (Appendix 18h).

The children were discussing their discovery (Appendix 18i):

> *I found this feather from the ground, what bird do you think it is?*
> *I think it is a small bird, as the feather is very small, maybe a pigeon?*
> *No, pigeons are quite big! Let's search for some birds and see.*

Here the children raised their own questions as a result of having the *freedom and time to explore.* It shows how their curiosity motivated them to raise further questions and find out more to extend their knowledge.

The number of questions that were raised was noticed by the trainees and associated with curiosity. Initially, the children questioned everything (TR2 39:34) which could have been as a result of their curiosity (Appendix 18j) as opposed to external motivators such as competition or teacher expectations (Ryan and Deci 2000). The children were able to raise more questions over time and this was attributed to the exploration of the stimuli in the outdoor surroundings (Constable 2017). Jelly (1985) suggests questions are generated as a result of direct contact with materials and are influenced by the nature of the materials. The number and quality of questions could also have been affected by teacher intervention, expectations and the modelling (Swann *et al.* 2012; Ward and Roden 2016). This increase in the number of questions did not necessarily relate to the quality of questions, which were often short one-step questions involving 'why', 'how' and 'what' (TR2 22:46, TR3 19:30, TR1 50:31).

The importance of stimuli (Waite 2011) in generating questions was reflected in the interviews of all three trainees (Appendices 16a, 16b, and 16c). This was noted in TR2's comment when she discussed the children's use of their senses "*We focused on sensory hunting then so when they physically touched something or were allowed to go and look at something they had more questions*" (TR2 3:50). The children were developing questions through close observation of the stimuli (Appendix 18k).

The number of questions asked by the 7-8 year olds working with TR2 over 5 sessions (Figure 21) shows that the number of questions that the children asked increased session by session. The trainees had already established relationships with the children, having been working with them in the Autumn Term, so this was not seen to be a factor in the increase in number of questions.

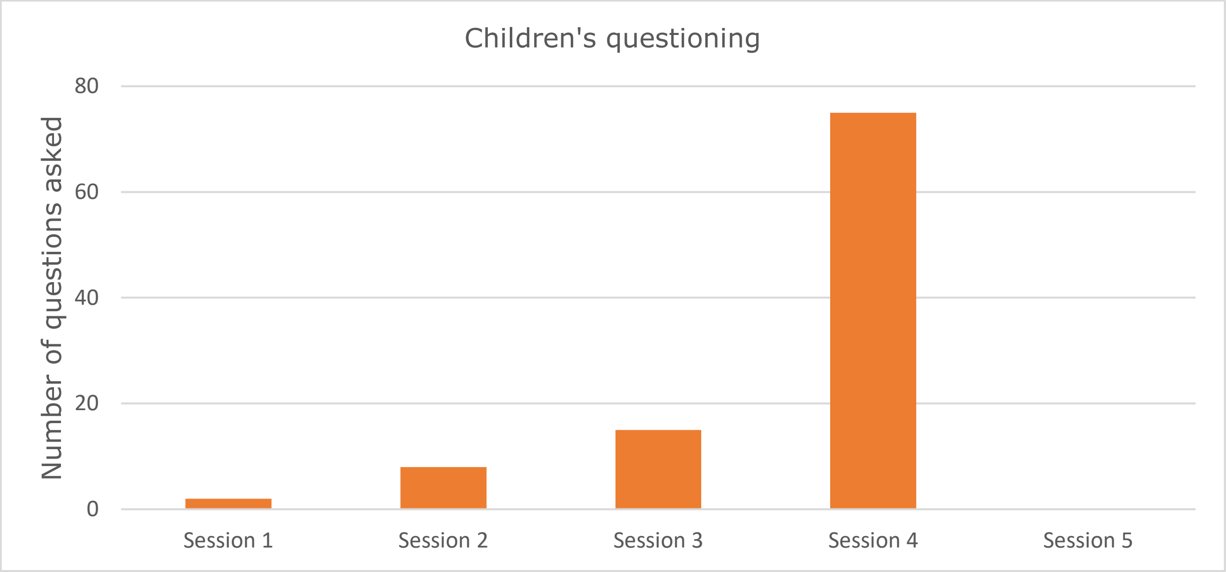


Figure 21: This shows the number of questions asked by the 7-8 year olds working with TR2 over 5 outdoor science sessions.

However, less curiosity was seen in a later session for TR2 (Figure 21) suggesting that without the stimuli, fewer questions may have been generated. In session 5, the focus was on sound in the outdoors which meant that children were unable to physically touch their investigative focus, which resulted in fewer questions being asked and therefore less curiosity demonstrated in the view of the trainee.

This lack of curiosity could have related to the teaching approach or the abstract nature of the content. The opportunity to interact with nature first-hand, provides children with real experiences, bringing science to life and creating a meaningful context for learning (Phillips 2015, Morgan, Franklin and Shallcross 2017, Grimshaw *et al.*, 2019). Outdoor learning experiences have been said to initiate curiosity about the world and this could be a factor encouraging pupil questioning (McCrory, 2018). This suggests that children ask questions based on their interest and wonder about concrete and observable phenomena.

There were occasions when the trainees questioned whether the children understood the *purpose of the questions*. Jelly (1985) suggested that these were unproductive questions that “promote science as information” (p48) but only reflected on the teachers’ questions in her work. Their questions were seen to be unrelated and led them off on a tangent (TR3 4:45, 5:10). They were observing other things around them. This divergence enabled the children to follow their interests and was a key principle of child-led learning (Johnson 2014) and it may be the role of the adult to harness this curiosity and make it relevant to make the most of the learning (Ward and Roden 2016, Black and Wiliam 2018). This was reflected in other examples that were interpreted as random questions (TR3 54:18, TR1 42:57). The questions were valued enough to be captured by the trainees and they seem to demonstrate the children's curiosity and interest in developing their scientific knowledge and behaviours.

11.2.4 Summary and contribution to knowledge

Examples of scientific behaviour in the outdoors was enabled through practical learning, child-led learning and opportunities to experience greater freedom within the learning. The children were observing over time, identifying and classifying, problem solving and they were able to articulate their scientific behaviours. They displayed scientific behavioural approaches such as risk-taking, decision-making, using prior knowledge, classification, accuracy, trial and error, comparing and contrasting results as well as learning from mistakes.

In terms of attitudes to learning, authentic and engaging science enabled children to question and demonstrate curiosity. They were making decisions and taking risks through using an inquisitive approach and having ownership of their learning. A holistic, personalised approach was used to inform future learning and enable empathy and responsibility towards nature. There were links between self-esteem, ownership of the learning and responsibility for the learning. Immersion in the outdoors and carrying out longitudinal studies outdoors influenced their attitudes, in particular creativity, persistence and uncertainty.

Curiosity was conveyed as a result of children being given the freedom and time to explore. The exploration of meaningful outdoor stimuli was found to relate directly to the number of questions being asked, the children's curiosity and their intrinsic motivation. The *number* of questions did not necessarily relate to the *quality* of the questions being asked. Some questions went off on a tangent and demonstrated divergence, but were authentic and valued, enabling the children to follow their interests and wonder.

The trainees identified examples of scientific behaviour which were found as a result of the children having had the freedom, stimuli and ownership of outdoor learning. It was necessary for the trainees to strike a balance between child-led learning and adult interventions whilst giving the children the ownership of the learning and empowering the learners. There is a need to develop the trainees' subject knowledge in relation to scientific behaviours and attitudes, which would aid their understanding and provide them with the confidence to further support the children's learning in primary science.

11.3 Chapter 3: ‘Questioning scientifically’ in the outdoors

The children’s questions demonstrated higher order thinking. The trainees were able to use the questions to document progression. The identification of misconceptions supported the children’s awareness of their own learning, demonstrating metacognition. The trainees became aware of the challenges associated with identifying, modelling and enabling questioning. Addressing these provided the children with a greater ownership of their learning, resulting in an improvement in the quality of the questions.

11.3.1 Evidence of a higher order questioning

The trainees documented ‘children’s questions’ (Jelly 1985, Chin and Osborne 2008) as opposed to the ones which they asked in the role of the teacher (Chin 2006; Harlen and Qualter 2018). All three trainees commented on the improved opportunities for children’s questions when working in the outdoors (TR1 6:40, 1:08:25, TR2 43:48, TR3 46:40). They stated that the learning was authentic, in a real-life context and stimulated more questions than working indoors (TR1 9:21, 56:58, TR3 8:50, 19:34, TR2 59:53, Appendix 18l). This was supported by Jelly (1985 p48) who suggested that children’s questions should “*have answers derived from first-hand experiences involving practical action with materials*”.

The trainees also commented on the quality of questions that improved along with the children’s skills of thinking scientifically. Examples of this included when the children used science experiences to explore ideas and raise different kinds of questions (TR2 37:32) and when children identified further questions arising from their results (TR1 27:19).

In the researcher’s analysis of the children’s questions, productive questions drew upon evidence, prior learning and made connections between ideas or involved reasoning. The key elements within the children’s questions, that were common across the evidence and trainees’ interviews, demonstrated these attributes:

- Investigative questions
- Questions that involve reasoning
- Cause and effect connections
- Prior learning connections

- Vocabulary and scientific concepts
- Purpose of the question through application.

The following are examples of *investigative questions* from Appendix 15. These questions show the child knows what to change (Independent Variable IV) and what to measure (Dependent Variable DV). These include:

- *Do bulbs grow quicker than seeds?* (IV: what is planted. DV: speed of growth)
- *Are ants the most popular [common] mini beast?* (IV: type of mini beast. DV: number counted)
- *Which food attracts the most insects?* (IV: food. DV: number of insects)

In asking these questions, the children applied their knowledge and understanding of 'working scientifically' by using their questioning for a purpose. The following evidence includes examples of questions which contain elements of *reasoning* (Appendix 15),

- *Where do they (birds) build the nests? How do birds build their nests?*
- *Why are we not finding any ladybirds?*
- *I wonder why we found it (worm) under the rock?*

They were challenging to categorise because the broadness of the definition of reasoning (Zimmerman 2005). In this situation, reasoning has been interpreted to mean questions that do not necessarily have a right answer, that problematise an issue and provide a stimulus for the development of ideas (Naylor and Keogh 2000).

Effective science learning was demonstrated through a range of *connections* that were identified in the children's questions. The following are examples of *cause and effect questions*. These involve making simple comparisons and identifying simple patterns or associations, as described in the 1999 National Curriculum (GB.DFEE 1999) and were often described as two-step questions by the trainees.

- *We are in winter, so do they (ladybirds) only come out in the summer?*
- *Why can you see water particles on the grass? How does water get back into the clouds?*
- *Do bulbs only grow in the spring? Do seeds grow any time of year?*
- *Seeds can be carried by animals and wind like dandelions but can bulbs?*

Another example of these *connections* was taken from the question hands (Appendix 18m) and was associated *with prior learning*. The children asked the question, "*What is* *friction?"* (TR2 19:30), which was seen to be unrelated to the outdoor learning opportunity. It was interesting to the trainee because, "*When I first started the placement they were already learning about materials and forces and we did a session or maybe two or three sessions on friction…with two experiments… yet outside they're still asking 'What is friction?'*". TR2 said that they had not retained the knowledge, but in fact, it may have been that they were drawing connections between their observations of fire lighting and their prior experiences, enabling them to apply their knowledge.

The children's *vocabulary and scientific concepts* support higher order questioning. Key vocabulary that was demonstrated within their questioning showed strong subject knowledge (Dunn and Peacock 2015) for the age related expectations found in the National Curriculum (GB.DfE 2013). This included examples of flora and fauna identification, fungi classification as well as snail and slug comparison. The children took an interest in sophisticated ideas involving processes and models that were beyond the National Curriculum expectations for their age (GB.DfE 2013). These included: shadow formation, speed of growth, evaporation, absorption and changes of state. These examples satisfy the criteria for synthesis questions in the matrix, which requires children to demonstrate the relevance of 'processes, phenomena, abstract ideas or models' (Appendix 2).

Trainee TR1 reported that children were asking investigable questions, which included raising questions based on their findings (TR1 30:32) and using observations to raise *questions with a purpose* (TR1 23:56). TR3 noted that the children were able to ask questions to investigate over time. They asked questions that led to the recording of data. Through their questioning, they explored connections through the seasons and insect preferences (TR1 40:16) for example:

- *Do other insects come out in the summer?*
- *Do they prefer sweet stuff?*
- *Which one do they prefer?*
- *How could I design a new home for a worm?*

Categorising the questions was challenging due to there being many ways of interpreting them. A number of questions could be categorised in a variety of ways and relate to multiple categories. However, interrogating the questions that children asked informed the trainees' ability to 'plan for' and 'enable' better questions to be asked by the children in the future.

11.3.2 Progression in children's questions

Progression in children's questions was observed in each case study. The trainees were clear that the quality of the children's questions improved over time (Appendix 15 question analysis; TR1 6:01, 35:33; TR2 42:18, 51:32; TR3 09:36, 50:31). They acknowledged where children exceeded expectations and analysed higher order questions in relation to the success criteria in the matrix.

As Goldsworthy and Feasey (1997) suggested, unlike other skills in investigation, it is very hard to identify a simple progression in the way children raise questions, as the level of difficulty depends on various factors such as the context and the language used. However, the trainees identified evidence of learning which demonstrated significant progressive steps in the children's questioning. These have been categorised in the following ways using three common concepts:

- Basic questions developed into investigable questions,
- Questions relating to exploration developed into questions with a purpose,
- There was a change from the children relying on the teacher, to the children taking ownership of their questions.

The trainees demonstrated the development of children's basic questions to more investigable questions. TR1 (TR1 36:07) described how the children moved from asking what, why and who questions through observing outdoors to more investigable questions where they were "*Deepening their questioning skills for them to actually secure that reasoning … they actually know what they are doing, what they are investigating and why*" (TR1 37:54). TR3 (TR3 10:28) also described 'what' and 'why' knowledge-based questions that became more sophisticated 'cause and effect' questions and investigable (TR3 50:31). The children began to raise new questions and predictions based upon what they had already found out in their enquiry (TR3 17:32 and 33:40). This was seen as higher order thinking (Zimmerman 2005).

All of the trainees commented on how questions based on exploration developed into questions with a purpose. They acknowledged that the children began to use their questions to find out about results in a scientific way. These included changes to their approach such as using reflective questions rather than simply exploratory questioning. The children were now focusing on 'how' they were learning rather than simply 'what' they were finding out about (Cohen, Chaput and Cashon 2002). This can be seen in the following example,

> *"I think that they realised that they could find their own answers to those things through enquiry so they stopped asking questions like, well the knowledge based questions, and I found that they actually started asking more questions like, and not even so much to me, they were more directing questions at each other so they were asking more questions like 'oh, well what did you find?', 'how many insects did you find here' or 'are our results the same?' and those higher order questions… then it was more like 'is what I found out reliable?' and they were asking questions about what they'd found more than what they wanted to find out."* (TR3 51:00). This demonstrates **analysis** in ideas, **application** in problems and **synthesis** in questions in relation to the criteria on the matrix.

This implied that the ownership of the learning shifted from the trainee as the 'more knowledgeable other' (Vygotsky 1978) to the children developing greater self-efficacy and peer-reviewing the learning by asking more questions to each other. This was supported by TR3 who noticed that children began to pose questions to each other (TR1 21:17, 38:41).

It was also found that the ownership of the learning through questioning shifted from the trainees to the children. Having ownership of the investigation led to higher order questioning for example:

> "So their questioning has developed throughout because they were then having that ownership in their investigation. This allowed them to raise questions of higher order thinking, "Oh, so I know I found insects in this area of the nature garden, so do they want to eat soil?"... so they put that in their food chamber. Then they wanted to investigate further, "Do they prefer sweet stuff?" so they were putting oranges in that chamber" (TR1 39:32). This demonstrates **analysis** in ideas, **application** in problems and **synthesis** in questions in relation to the criteria on the matrix.

The children were able to ask questions that resulted from their enquiries, including comparing results and findings, and they made observations over time rather than expecting an instant answer from a knowledge-based question.

There was a shift in children's understanding (Appendix 15) that showed how the children's questioning moved from simply asking questions, to asking questions to which they knew they could find the answer. This was evidence of self-efficacy (Bandura 2001; Gutmas and Schoon 2013). According to Harlen and Qualter (2018), children who realise that they can find answers to their questions, for example by answering them through scientific enquiry or through their own interaction with things around them, are more advanced in their scientific development. This was reflected in the interview with TR1 where she considered the importance of asking investigable questions, which included raising questions based on their findings (TR1 21:50, 30:32) and using observations to raise questions with a purpose (TR1 23:56, 26:18).

The children demonstrated progression by realising that they could find their own answers to their questions through enquiry, so they stopped asking the knowledge-based questions. They began to direct questions to each other and ask questions like "*What did you find*?", "*How many insects did you find here?*", "*Are our results the same?*" and "*Is what I found out reliable?*" (TR3 51:00). These were deemed to be higher order questions associated with having ownership of the learning.

Having a better understanding of the questions that children ask, enabled the trainees to extend the children's scientific abilities. Understanding the progression allowed them to identify the next steps in learning. The higher order thinking skills were identified in the children's questions and the children demonstrated a greater ownership of their learning, thereby showing improvement in metacognition.

11.3.3 Identifying misconceptions in children's questions

Ofsted (2021) commented on the teachers' role in 'supressing' and 'challenging' misconceptions with a focus on knowledge rather than skills. However, there is a case for making children aware of their misconceptions through metacognition and reasoning. The children's questions were deemed to be a valuable way of identifying the children's *conceptual misconceptions*. As a result, the misconceptions were identified and the answers were found alongside the child (Appendix 15).

In this example, the child demonstrated partial knowledge and applied logic but didn't understand the process of plant reproduction.

- *How do trees fit inside a seed? (example #1)*

It was evident from the trainee's comment (TR3 5:28, 32:11) that the authentic experiences helped the child to address their own misconception through the exploration of plant lifecycles. The importance of language in communicating and reflecting critically (Harlen *et al*. 2003) can also be seen in the following examples (Appendix 15):

- *Why is the moon sometimes out in the morning? (example #2)*
- *How do fish breathe underwater? (example #3)*
- *How do puddles disappear? (example #4)*
- *How does water get back into the clouds to evaporate? (example #5)*
- *Why do mushrooms eat wood? (example #8)*

The adult may need further clarification from the child. For example, the child may not know the correct scientific vocabulary to use to express the point they are making but their knowledge may be sound i.e. the moon is out rather than visible, breath rather than gaseous exchange, evaporate rather then disappear, absorb or digest rather than eat. In the next example, rather than stating that plants absorb nutrients, the child shows their misconception when applying their prior knowledge by using the term food.

- *Why do they get food from the roots? (example #6)*

These examples could stem from terms that the trainees have used or they have been exposed to at home or on digital technology (Loxley *et al.* 2018; Osborne, Wadsworth and Black 1992). It has been acknowledged that the use of everyday language, such as food for plants, can form misconceptions (Harlen *et al*. 2003). In the next example, the child has a lack of understanding of the term flavour.

- *How does the flavour blackcurrant get into the flower? (example #7)*

In order to support this child's next learning steps, the misconception needs further discussion with the child for greater clarity. In this case, it may be due to a lack of experience and sensory exploration or it could be as a result of a lack of knowledge of the parts of the plant and the purpose of plant reproduction.

11.3.4 The challenges associated with assessing children's questions

Whilst considering progression with children's questioning, the trainees identified several challenges that they had to overcome in order to assess the children's learning. These included:

- Capturing and assessing the children's questions
- Modelling the skill of questioning
- Enabling purposeful questioning

Capturing and assessing the children's questions with a child-focused approach was challenging. The number of questions and the quality of questions was affected by the need for the recording of the questions to be a captured live 'in-the-moment' (TR1 1:00:19) and was impacted by the environmental conditions and freedom of movement (TR2 21:06). Having time to analyse and moderate questioning was valuable, as was demonstrated by one trainee who did not realise the quality of the learning until they were reflecting on the learning evidence in the interview (TR2 27:38).

In terms of teacher-facilitated learning, Chin and Brown (2000) suggest supporting and extending children's questions rather than letting it happen organically. Chin and Obsorne (2008) and Smith (2016) suggest the use of question stems which was applied by TR1 (TR1 27:19). This trainee used the question stems as a prompt to help children to raise questions. They were thinking more deeply and using what they had found and observed in the outdoors (TR1 38:41). The children produced a greater number of questions (TR1 48:15). The question stems helped to draw out their ideas in their investigations (TR1 38:18), also encouraging sophisticated questions that were unexpected and frequently led on from their investigations (TR1 41:15).

To make more progress within questioning, whilst assessing the children's practical science learning outdoors, the children's questions needed to have a greater purpose. *Enabling purposeful questioning* through child-led learning was a priority for the trainees. In order to increase the children's awareness of the purpose of their questioning, the trainees discussed a range of strategies that they implemented in the role of a facilitator; some of which were evident in their field notes and reflections (Appendix 18).

- Enabling the children to understand why they were asking these questions (TR3 3:25, 8:50).

- Supporting them to retain the question that they asked (TR1 02:58).
- Enabling them to find the answer for themselves in order to retain the answer (TR2 19:55, 43:48).
- Support children to raise productive questions that promote science as a way of working (TR1 23:56).

These examples of a facilitative approach to teaching provided the children with a greater ownership of their own learning resulting in an improvement in the quality of the questions when captured through assessment. There is little that has been written about supporting teachers in knowing how to extend children's questioning. Harlen and Qualter (2018) and Jelly (1985) only look at how practitioners can respond to their questions rather than teaching them to take ownership of their questions. Most of the other research in this field deals with responding to children's answers to teacher's questions (Mercer, Dawes and Staarman 2009, Dawes 2011 and Alexander 2017). This evidence provides examples of ways of supporting children with a greater emphasis on child-led learning. This in turn will supported metacognition (Quigley, Muija and Stringer 2018) and self-regulation (Zimmerman 1995).

11.3.5 Summary and contribution to knowledge

The focus on children's questions as opposed to teachers questions allowed a child centred approach, highlighting the importance of their place within thinking scientifically.

The vocabulary and application of the question became increasingly more sophisticated within the higher order questions. The range of children's questions included investigative, reasoning and those that involved connections. Children's ownership and understanding of the type and purpose of the questions demonstrated metacognitive awareness over time.

Progression was noted when the children asked questions of one another and when their questions related to the findings. When the children took ownership of finding out their own answers, the questions had purpose. The ownership of and reflection upon the questions allowed the children to understand why they were asking the questions, enabled them to retain the questions they had asked and promoted productive questions to which they could find the answer themselves.

Focusing on the children’s questions enabled the trainees to assess the children’s understanding and their misconceptions in order to enable progression. It was necessary for them to consider the expectations relevant to the age and ability of the children.

11.4 Summary of the discussion

When looking at what constitutes effective science outdoor learning, the evidence highlighted the significance of thinking scientifically in outdoor contexts. The trainee teachers based in each of the three schools used the matrix to chart and reflect on the ways that children were ‘thinking scientifically’ through assessing and analysing the science learning in the outdoors. The matrix aided the trainees’ confidence and enabled them to more effectively plan and assess the learning from which there was no starting point.

Exemplification of the learning was demonstrated through a range of dispositions including:

- *Thinking scientifically* skills where expectations were exceeded to include skills that align with analysis, synthesis and evaluation based on Bloom *et al.* (1956).
- *Scientific behavioural* approaches beyond procedural enquiry skills, to include risk-taking, decision-making, using prior knowledge, classification, accuracy, trial and error, comparing and contrasting results as well as learning from mistakes.
- The children’s *questioning* which became more sophisticated through the type and purpose of their questions. This included asking more complex questions with stronger vocabulary choices such as those that were investigable and those that drew connections, include reasoning or cause and effect.

Learning that resulted from the immersion and freedom associated with the outdoors, also established a range of principles including:

- A *child-led* approach resulting in stronger ownership of the learning and the next learning steps, though the demonstration of *metacognition*.
- A *holistic* approach involving identifying the *attitudes* within children’s scientific behaviours, including curiosity, motivation and passion for learning. This also involves wider aptitudes including creativity, persistence and uncertainty.

- A *progressive* approach which identifies shifts in learning and includes the development of higher order thinking. Firstly, random and abstract ideas advanced to more purposeful and complex thinking, secondly, single-step changed into multi-step and investigation-led learning, thirdly, exploration developed into consolidated learning and demonstrated application of prior knowledge.

‘Thinking scientifically’ was central to the three dispositions which were identified within outdoor learning. This enabled successful science through purposeful, authentic learning opportunities and high learning expectations.

As a result of learning about science in the outdoors, the children overcame initial misconceptions and acquired a greater understanding of the purpose of science. They improved their scientific literacy and developed life skills with the potential to provide scientific contributions to the world (ACARA, 2014).

Conclusion

12.1 Summary

Outdoor education is often seen as "risky fun" (Glackin 2016, p.1). This thesis challenges these perceptions of the outdoors as being less academic by repositioning outdoor learning as a pursuit for the obtainment of authentic science by "getting more from getting out" (Scott and Boyd 2016, p.1). It provided trainee teachers with the tools, confidence and autonomy to facilitate learning outdoors. Through the use of the matrix, it was revealed that when learning science is based in the outdoors, young children are well-placed to demonstrate higher-order thinking skills beyond those expected of them within end of Key Stage outcomes (GB.DfE 2013). The evidence showed how children were able to reflect upon their learning in order to develop higher-order scientific thinking skills, demonstrate scientific behaviours and question in a scientific way. Capturing the skills, knowledge and understanding that children developed in relation to thinking, behaving and questioning scientifically was seen to have value in acknowledging that *real* contextual learning had taken place.

This thesis focused on assessing the learning in-the-moment through qualitative critical incidents (Tripp 2012) rather than through gathering perceptions about learning or through a post-learning test, as can be seen in the research from Scott and Boyd (2016). The use of the matrix, as a research tool, provided a platform to aid the trainees in capturing outdoor science learning. It helped to generate data that provided insight into outdoor science learning and displayed key learning outcomes that were successfully achieved during the learning process. The data also informed how the matrix might be developed in the future.

Within this research, outdoor science learning was found to enable higher-order learning, enhanced personal interest and motivated the children to learn. The findings highlighted the benefits of learning science outdoors, including the freedom of choice and the opportunity to solve problems. These enabled the learners to demonstrate the dispositions of 'thinking scientifically', 'behaving scientifically' and 'questioning scientifically' through topics such as the process of growth, respiration and reproduction, the water cycle and changing state, seasonal change and weather, shadows, ecosystems and environmental impact. All of these concepts became more concrete when explored within *real* contexts. Whilst it was necessary to acknowledge the debate about the novelty of learning outdoors (Orion and Hofstein 1994; Aikenhead 1996; Waite 2007), this research has provided evidence of the development of scientific attainment. Experiencing science through learning *in situ* allowed the children to make strong connections to the learning content.

By contrast to much of the literature on outdoor science (Waite 2011, Glackin 2016, Harris 2017) that focused on professional perceptions and confidence, the findings show the ways that outdoor learning is specifically conducive to the support and facilitation of primary science education. The evidence from this thesis supports trainee teachers' understanding of the value of outdoor learning and enables them to have the autonomy to use it within science learning. It also provides evidence to help convince leaders and policymakers of the educational benefits of learning in the outdoors, beyond those associated with wellbeing and social development.

Bianchi, Whittaker and Poole (2021) present classroom findings as seen through the eyes of primary science specialists and represent their existing knowledge and experience, which is used to debate and increase coherent connectivity towards the improvement of pupil outcomes in primary science. In response to their ten key issues with children's learning in primary science in England (Bianchi, Whittaker and Poole 2021), the evidence from this thesis directly relates to five out of ten of their issues. Particular strengths from the evidence of learning science outdoors include:

- the depth of the new learning (issue 1),
- the autonomy and independence that was demonstrated by the children, (issue 4),
- learning which was authentic and had purpose (issue 7),
- learning which drew on prior learning and occurred regularly (issue 8),
- the children were encouraged to use their own curiosity, scientific interests and questions in their science learning (issue 6).

This research provides primary subject specific evidence of child-centred learning and examples of where the issues can be improved.

12.2 Identification of the gaps in knowledge

This thesis makes contributions to knowledge where apparent gaps were identified including:

- There was a lack of **research** focusing on the learning outcomes, quality of learning and impact of this learning on the children's attainment.
- The gap in **research** into the use of children's scientific questions in the outdoor as an assessment tool.

Over the course of the study, two more gaps were identified relating to practice and learning:

- This lack of knowledge and evidence has implications for assessment and moderation processes within schools and implies that there is a gap in **practice**.
- The trainees demonstrated the successes in learning but also highlighted gaps in children's **learning** in terms of analysis, synthesis and evaluation.

These gaps have been fundamental in the direction that the research has taken and have led to the identification of the key findings.

12.3 Key findings and responding to the subsidiary questions

The key findings have been reflected upon and related to the underpinning research questions. The aim of the research was to find out how trainee teachers can most effectively support children's learning in primary science, using the outdoors. This is responded to in the recommendations and final reflections in light of the responses to the following questions.

- The main question was: *What constitutes effective outdoor science learning?*

Trainee teachers needed to understand what effective learning looked like in order to successfully support children. The matrix provided this support, resulting in effective learning outcomes. Similar to 'Assessing Pupils' Progress' (DCSF 2009), the matrix provided the steps to personalise the learning of the child and make secure judgements about the standards of learning and what the children need to do next. It was outdoor specific and strengthened existing practice through the use of outdoor learning evidence, moderation of assessment and subsequent intervention.

The findings relating to the subsidiary questions were key to exemplifying the learning and providing evidence that contributed to supporting trainee teachers to understand how this can be achieved in the outdoors.

- *What evidence is there that children are thinking scientifically in the outdoors?*

There were common findings across all three cases. Each case used a child-led approach, with the child taking the ownership of the learning. Higher-order thinking resulted from self-efficacy, stronger peer-review, drawing connections and involving reasoning. Examples of the learning were captured in Appendix 17. Two examples of effective learning include, firstly, the learners demonstrated that they could make science predictions and as a result 'use what I already know to help me explain new things'. Secondly, their understanding progressed from being able 'to name' to the children being able 'to explain ideas, processes and phenomena' such as describing the function of the petal within the reproduction of the plant. The evidence of thinking scientifically was captured through identifying a range of relevant scientific skills and attributes (section 11.1). They were able to identify misconceptions and find out the answers alongside the child. The children were asking questions resulting from their findings, comparing and observing over time. Their questions changed from simply asking questions to asking questions to which they knew they could find an answer. Knowledge and understanding became stronger including sophisticated concepts including processes, phenomena, abstract ideas and models.

- *What scientific attitudes are demonstrated by the children when learning in context?*

The learning was conceived of as authentic because it was based on real, sensory, child-led learning and it had purpose. Outdoor learning offered opportunities for authentic and engaging enquiries involving freedom and choice, simulation, motivation, question generation, risk taking and decision making (section 11.2.2). Learning within a meaningful context developed curiosity, interest and wonder. There was a greater appreciation for nature and the world around them. This was seen to be supporting the development of their life skills. Questioning, in particular, was related to curiosity and emphasised by sensory experiences and exploration. Positive attitudes were associated with authentic, real-life examples and there was an understanding of importance of having a purpose to the learning.

- *How do trainee teachers know if their children have made progress with their science learning in the outdoors?*

Through the use of the matrix, the trainees moved beyond being able to describe the learning and were able to comment on achievement. Significant progressive steps in the learning demonstrated greater complexity and resulted in the children having greater ownership of the learning and self-efficacy. The evidence relating to the matrix (Appendix 17) suggested that the children achieved age related expectations or higher within 'working scientifically'.

Knowledge and understanding were the categories from the matrix that were most commonly referred to during the interviews. It has been suggested that they underpin the other forms of learning, yet the trainees recognised that questions relating to facts, knowledge and understanding were lower order when simply related to recall and memory. However, there were differences in the quality of the questions as a consequence of changes to the purpose and level of reflexivity, where they focused on *how* they learnt and not just on *what* they were learning. The trainees recognised higher-order thinking involved in investigative and application questions. They also understood the value of reasoning and cause and effect questions.

When knowledge and understanding were referred to in relation to synthesis and evaluation, strong subject knowledge was required i.e. including sophisticated concepts linked to processes, phenomena, abstract ideas and models. It was challenging to define and categorise philosophical and evaluative questions. In terms of progression, it was inferred that these types of questions required a sophisticated understanding of the context and a creative application of ideas. The 'Big Questions' were acknowledged by Harlen (2010) who highlighted their value in relation to the scientific skills of reasoning and evaluation.

- *What are the challenges associated with assessing children's practical science learning outdoors?*

There was a sense of an emerging ill-fit between official policy instruction and the possibilities for using outdoor learning to facilitate primary science education.

Government documentation in science assessment (STA 2019) was not deemed by the trainees to be compatible with outdoor learning and they were consequently less confident in judging the attainment of the children in science than they were in the other core subjects.

Additionally, progression in thinking scientifically was sometimes hindered by the following factors: the time provided for outdoor learning, the trainees' awareness of scientific skills and behaviours, together with the children's abilities to making connections, reason and provide detail within their learning experiences. There were also gaps in evidence of learning in terms of analysis, synthesis and evaluation (section 11.1.4).

Some of the limitations relating to thinking and behaving scientifically across the case studies can also be understood as a result of:

- Age, ability and skill level of the child
- Children's prior experiences
- Availability of time dedicated to learning in the outdoors
- Initial teaching experience and expectations
- Teaching and learning opportunities and purpose
- Trainees' confidence.

It was noted that age did not limit the attainment of the highest expectations. However, vocabulary choices restricted the range of expression for the youngest children although aligned otherwise with their wider social and communication skills. These insights have helped to inform recommendations and adaptions to enable the matrix to be used more effectively.

12.3.1 Reflecting on the value of the matrix

The matrix gave the trainee teachers concrete support to enable the learning and teaching to be more effective. It was used to track the progress of individual children and enabled the trainees to intervene appropriately. It supported the trainees to know where the children were, where they needed to be and how to get there. As the matrix was based on the current English National Curriculum (GB.DfE 2013), it could also provide teachers and educational leaders with the confidence to embed this within their own practice.

Continued use in practice will ensure it is further refined and trainee teachers can adapt it according to their needs. It is not age-specific and therefore can be used across the learning and teaching of primary aged children. Although the matrix was designed to be applied in outdoor context, the flexibility within it may enable it to be used in a wider variety of practical scientific contexts in line with research such as the approaches in Project Calibrate (Erduran *et al.* 2020), Teacher Assessment in Primary Science (TAPS) project (PSTT 2015; Earle 2018; PSTT 2021), the government's teacher assessment exemplification (STA 2018b) and Planning for Assessment (PLAN) (ASE 2018a).

In light of the findings from this study, the matrix could be adapted in order to make it even more effective. For example, including success criteria for children which take into consideration the following:

- The purpose and complexity of their scientific thinking
- The purpose of their actions and behavioural approaches
- The purpose of their higher order questions
- The child's ownership of their learning
- Their metacognitive skills
- Their awareness of their scientific skills
- Their application of prior knowledge
- Their appreciation of changes over time
- Their ability to use multi-step and investigation-led approaches
- Their ability to make connections explicit
- Their ability to demonstrate detail, quality and accuracy
- Their ability to demonstrate scientific attitudes
- Their ability to reason.

There would also be benefits in populating the matrix with age-specific examples, developing it nationally and standardising it with further outdoor science learning examples (Figure 16, Figure 18 and Appendix 17).

12.4 Methodological limitations

All research is subject to some limitations and it is important to identify these to provide a well-rounded account of what my thesis contributes to knowledge and practice. Regarding this, the limitations associated with the three methods of documentary analysis, observations and interviews, can be considered in relation to the mitigations put in place and the benefits of the methods in the context of this research (Appendix 19).

Within the **documentary analysis**, the evidence of learning involved snapshots in time which were non-replicable and, although they captured the dynamic and ever-changing aspects of human nature, they were also valued for their authenticity and trustworthiness (Wellington 2000). Within the consistency of recording **observations**, there were challenges associated with collecting the evidence of learning. This was mitigated by working with the trainee teachers to develop the booklets as a fit-for-purpose way of recording the learning with the intention of providing consistency. Within the **interviews**, recording learning conversations in-the-moment were understood to be more challenging for trainees to document than those that were reflective post-learning. This was mitigated using electronic devices and establishing routines which had been developed through the university training.

The thematic analysis enabled the identification of codes and themes (Appendix 13a, 13b, 13c and Appendix 14) and can be understood as methodologically subjective. However, while there were possibilities in terms of developing connections and generating themes, my insider position as a teacher and teacher trainer, enabled me to apply my knowledge of the curriculum and pedagogy when making these judgments.

The reliability of the results was limited by the sample size, which was restricted to three cases, three trainees and eleven children (Figure 6b). As I was not intending to make positivist claims, I did not directly compare the case-study schools, the practice of the trainees or the achievements of individual children (Silverman 2011; Stake 2006). However, a range of perspectives provided multiple realities because understanding was influenced by contextual factors such as the schools' outdoor space, the time available, trainee confidence and the engagement of the children. Triangulation was used to provide multiple interpretations of the documents that were being analysed. This provided confidence in credibility and plausibility of the research (Wellington 2000, p.201).

Finally, COVID-19 had an impact upon the breadth of data collection because the time available for the trainees to work with the children was curtailed. For example, trainee TR1 had an enquiry with observations set up over time, which she believed may have resulted in further higher order learning and a greater number of questions being identified as a result. The length of the data collection period was dictated by the final date of placement, which made the parameters easier to judge as opposed to judging when a saturation point was reached.

Face to face interviews became online synchronous interviews which may have affected the trainee's ability to refer to the full extent of their data and experiences. However, this approach was found to be more accessible and less intrusive. Having finished their final year at university, the trainees found that it was convenient to meet virtually. In line with the ways of working on their degree course, the trainees were able to share the evidence on the screen which kept the discussion focused and evidence informed.

12.4.1 Bias

A degree of bias was inevitable as analytical choices were made continuously and this could have impacted upon the validity of the study. I was aware of my own potential bias within the data analysis when deciding what to leave out, what to highlight, what to report first and last, what to interconnect and which main ideas were important (Wilcott 1995). My values and preferences along with a requirement for reflexivity informed my thinking and bias could not be eliminated in this qualitative research (Lichtman 2006). However, as an external insider (Costley 2019), and as a trained teacher, Forest School leader and university lecturer in schools, I had an understanding of the learning and processes involved. It enabled me to be analytical and validate or challenge interpretations by offering alternative perspectives. The interpretation of the children's actions and trainee interviews was also supported by the use of multiple data sources. Finally, trainee perspectives were sought to validate, qualify and support the findings where they were acting as critical friends (Yin 2018) to reduce researcher bias.

There was also the potential for trainee bias, such as deciding what to notice and what was significant about the children's learning. The trainee teachers knew the expectations of the child in other areas of learning and may have let this influence their perceptions. Also, they may have wanted to present results that would be of value to me and this research. In mitigating this, the trainees' ability to identify significant learning moments had been developed through the taught course. The design of the booklets supported the trainees in deciding the parameters for what data to collect in response to the research questions. When it was necessary to scribe for a child, they were aware of the importance of representing the children's ideas accurately. I appreciated the wide range of responses in the fortnightly meetings and modelled how all responses were valued.

To ensure that there was no additional pressure put on the trainees' placement experience, I made sure that I was not their university-based school lecturer, therefore, I was not responsible for moderating judgements about meeting the teaching standards (GB.DfE 2011; GB.DfE 2019). The assessment of children's learning was also not directly related to the child's progress upon which the school, class teacher and trainees were judged (STA 2017a).

12.4.2 Tensions and mitigations associated with working with trainees

The trainees were involved within this collaborative approach ensuring that the research was done with them and not to them (Costley and Fulton 2019). The trainees acting as facilitators were informed of, and were in agreement with, the research priorities and ethical values. This emphasised the importance of sharing the ethical philosophy and principles with them to support their decision making; ensuring that measures were put in place to prevent, minimise or respond to distress.

As a result of their active involvement (Figure 5), the trainee's demonstrated heightened interest and awareness of the research and the process. Their high level of involvement may have had an indirect impact on their grades. In terms of consistency, the trainees were given the same 1:1 supervision time as the other trainees studying on the dissertation module. Whilst tutorials were personalised according to their needs, any supervisory differences were in line with the module handbook, course specifications and assessment standardisation (NTU 2020). All three trainees chose to study at Masters level for the fourth year of their degree, before they volunteered to take part in this research, which demonstrated their motivation and their willingness to improve their understanding of their own practice (Schon 1991). The benefit of working with science specialists was that their subject knowledge and personal motivation meant that they were in a strong position to collect meaningful data. Their involvement had a dual benefit in making them more employable through showing their commitment to science learning and their proactive approach to research informed practice.

It was important to ensure that there wasn’t an unfair advantage for those involved. For the trainees, the use of pre-existing tools minimised the perception that there was an unfair advantage for those involved. The ‘learning-in-action’ booklet (Figure 7) and the ‘thinking scientifically’ matrix (Figure 8, Appendix 2) were shared with the whole cohort in their third year as tools for data collection and assessment within primary science. There were times that the trainees referred to research evidence to support their professional practice. They used it to their advantage in their assignments, Professional Development File (PDF) and final progress meeting, where they demonstrated that they had met the teachers’ standards (GB.DfE 2011).

Enabling the trainees to be selective of the evidence in-the-moment and within the interview may have limited the breadth of the interpretation, however the interpretation of data was strengthened due to their insider positioning. They were also cautious about showing how they ‘made sense of’ and ‘transformed’ their experience into consciousness in order to find meaning (Patton 2002), for example when recognising specific examples and noticing connections. As they needed the confidence to challenge or seek clarification in relation to their experiences, I provided an opportunity for sense-checking to enable participants to qualify or modify their reflections and articulate the learning or viewpoints. In light of the reflections, the trainees were surprised at the quality of examples that they had collected over the research period.

The evidence from the data collection was susceptible to a degree of subjectivity. The trainees’ perceptions of reality could have been influenced by their insider knowledge of the children, their opinions and personal bias. I attempted to distinguish between justified belief and opinion through encouraging the trainees to demonstrate their points with examples of the learning. I supported the trainee teachers in identifying their own bias within their interpretations. Enabling trainees to acknowledge their own biases provided greater insight into the learning and more reliable findings.

12.6 Recommendations

This thesis has led to the identification of the following recommendations which will inform the teachers trainees' actions in effectively supporting the children's learning in outdoor primary science.

Recommendations **for the children's science learning outdoors**:

The next steps in 'thinking scientifically' include: using scientific evidence, building in more opportunities for reflecting and self-evaluating, also, extending vocabulary choices through the development of their subject knowledge.

The next steps in 'behaving scientifically' include: meaningfully exploring stimuli over time, taking more responsibility for and ownership of the learning, as well as articulating scientific approaches, for example decision-making and risk-taking, and attitudes such as empathy for nature.

Next steps in 'questioning scientifically' would be to:

- improve their awareness of the purpose of their scientific questioning
- understand why they were asking the questions
- retain the question that they had asked
- find the answers for themselves
- raise productive questions
- understand their next steps in learning science outdoors

These recommendations provide the trainee teachers with tangible examples of how they can enable effective outdoor science learning. The three dispositions are integral to the improvement of children's outdoor science learning and their professional practice.

Recommendations **for trainees as teachers**:

In order to extend the children's outdoor science learning further, the next steps for trainees would be to:

- increase subject knowledge associated with thinking and behaving scientifically
- enable scientific attitudes to lead the learning
- understand progression in questioning
- understand what the children's next steps in outdoor science learning would be
- work with evidence to support assessment
- understand the balance between child-led learning and teacher-led intervention

These are in line with the work of Sharp *et al.* (2021) regarding the role of the adult as a facilitator working with children learning science outdoors which is comparable to the Foundation Stage approach. Although the evidence from the research along with these future recommendations illustrates the value of outdoor science learning, practice may continue to be limited by the restrictions on teachers' professional autonomy.

Recommendations **for qualified teachers and leaders in education**:

To ensure that the teaching of science in the outdoors is undertaken successfully, teachers could use the evidence within this research to support their practice. They could use the expectations and exemplification as a basis to enable them to pitch the learning at an appropriate level. The application of the matrix will provide practitioners and leaders with the confidence to facilitate and thereby further the learning, thus unlocking the wider educational benefits.

Recommendations **for my own practice as a teacher educator**:

The intention is to use the recommendations from this research to **design a refined matrix, which is the first of its kind in outdoor science education, to support educators to 'pitch expectations' for progression** in children's scientific learning when based outdoors.

This will be used with third year trainees on the taught course and fourth year trainees on future placements. Within this, it will be beneficial to collect more examples of the children's outdoor scientific learning, to provide greater depth and to enable the matrix to be more reliable. This will involve working with trainee teachers, partnership schools, early career framework hubs and science specialists from wider schools who are involved in working towards the primary science quality mark. Dissemination of the findings will be through meetings, research conferences and publications with the aim of influencing of school leaders and the government.

12.7 Final reflections

The focus for this thesis was to answer the research question: 'How can trainee teachers most effectively support children's learning in primary science, using the outdoors?'. The recommendations derived from this this thesis will not only answer the question but will also help to facilitate the improvement of science attainment. Additionally, the evidence-based pedagogical research emphasises specific advantages of outdoor learning but also acknowledges the restrictions on teachers' professional autonomy.

Teachers and educational leaders can be encouraged to invest in the key messages of valuing outdoor science and understanding progression, expectations, behaviours and attitudes. This investment, together with the implementation of the recommendations, will go towards closing the gaps in knowledge that were identified throughout the thesis making this research worthwhile and pertinent.

The practical elements of outdoor science learning are abstract in principle and challenging to capture. The matrix provides guiding criteria. The practical examples provide exemplification of this criteria. Moderation discussions are one way to improve the reliability of the judgements in order to support teachers to better understand the criteria and progression in outdoor science learning.

Further questions arising from this thesis which could form the basis of future research include:

- To what extent can the matrix (Figure 8) be applied to other contexts, phases of education and subjects?
- How could the matrix be used to support planning for learning?
- How can the teacher adoption of the success criteria be further embedded?
- How does learning change over a longer period of time?

In light of the COVID-19 restrictions on free movement and the impact of digital technologies, there is an ever-increasing need to get the children out and into nature with the intention of giving them the scientific, higher order and life-skills that they will require in order to succeed in the future (Spring 2018, Quay *et al*. 2020). The pandemic highlighted the need for scientists within our communities and the value they bring to government decision making (Hodges *et al.* 2022; Koch and Durodie 2022). This way of working will in turn encourage children to strive to secure STEM or science-related careers which has been emphasised as being important globally (ACARA 2014) and will contribute to children's ‘Science Capital’ (Archer *et al.* 2015). The findings from this research require further trialling and refinement for age phases and contexts. This research will support the future of outdoor learning and teaching in outdoor science education.

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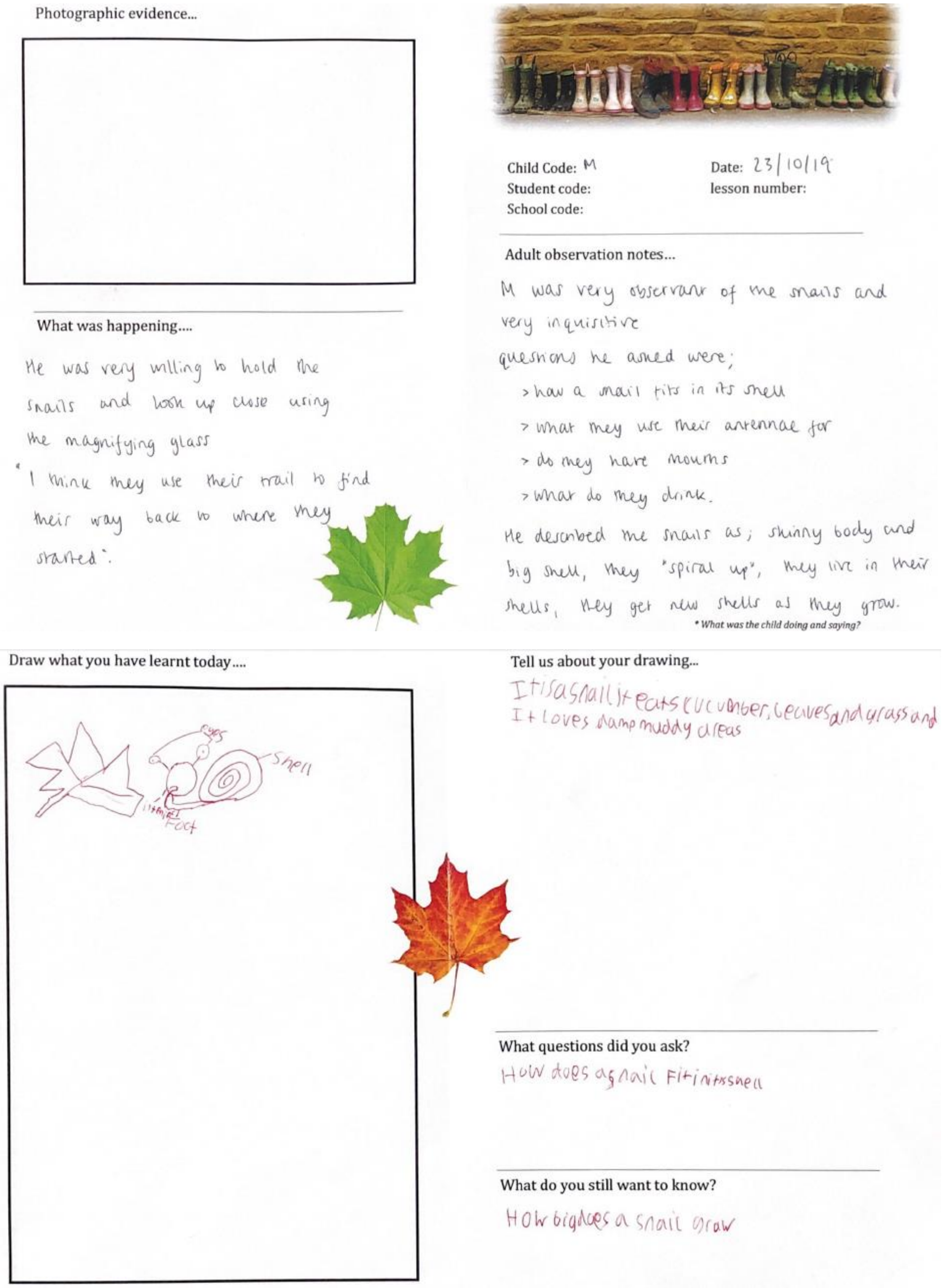
Appendix 1: Completed example of a ‘learning in action’ booklet



Photographic evidence...

What was happening....

He was very willing to hold the snails and look up close using the magnifying glass

"I think they use their trail to find their way back to where they started".

Draw what you have learnt today....

Child Code: M
Date: 23/10/19
Student code:
lesson number:
School code:

Adult observation notes...

M was very observant of the snails and very inquisitive

questions he asked were;

> how a snail fits in its shell
> what they use their antennae for
> do they have mouths
> what do they drink.

He described the snails as; shiny body and big shell, they "spiral up", they live in their shells, they get new shells as they grow.

** What was the child doing and saying?*

Tell us about your drawing...

It is a snail it eats cucumber, leaves and grass and It loves damp muddy areas

What questions did you ask?

How does a snail Fit in its shell

What do you still want to know?

How big does a snail grow

Appendix 2: ‘Thinking scientifically’ matrix

Learning outcomes	Links to teaching	Success Criteria					
		Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
Thinking scientifically	I - Ideas	☐ Use abstract ideas or models or multiple factors when explaining processes or phenomena	☐ Use abstract ideas or models or more than one step when describing processes or phenomena	☐ Use scientific ideas when describing simple processes or phenomena	☐ Identify differences, similarities or changes related to simple scientific ideas, processes or phenomena	☐ Draw on their observations and ideas to offer answers to questions	☐ Ask questions stimulated by their exploration
	P - Problems	☐ Identify the strengths and weaknesses of particular models	☐ Explain processes or phenomena, suggest solutions to problems or answer questions by drawing on abstract ideas or models	☐ Use simple models to describe scientific ideas	☐ Respond to ideas given to them to answer questions or suggest solutions to problems. Represent things in the real world using simple physical models	☐ Make comparisons between basic features or components of objects, living things or events	☐ Recognise basic features
	E - Evidence	☐ Describe some scientific evidence that supports or refutes particular ideas or arguments, including those in development	☐ Recognise scientific questions that do not yet have definitive answers ☐ Identify the use of evidence and creative thinking by scientists in the development of scientific ideas	☐ Identify scientific evidence that is being used to support or refute ideas or arguments	☐ Use straightforward scientific evidence to answer questions, or to support their findings	☐ Sort and group objects, living things or events on the basis of what they have observed ☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) needed to answer a question	☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) that has been used to answer a question
	Q - Questions	☐ Explain how new scientific evidence is discussed and interpreted by the scientific community and how this may lead to changes in scientific idea	☐ Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience. ☐ Identify further questions arising from their results. ☐ Make predictions using scientific knowledge and understanding	☐ Use their science experiences to explore ideas and raise different kinds of questions ☐ Use their results to make predictions	☐ Raise their own relevant questions about the world around them. ☐ With support, they should identify new questions arising from the data, making predictions for new values within or beyond the data they have collected and finding ways of improving what they have already done.	☐ Explore the world around them and raise their own simple questions	☐ Draw on their experience to help answer questions. Show curiosity about objects, events and people. ☐ Question why things happen

Appendix 3: Original ‘working scientifically’ matrix

Learning outcomes	**Links to teaching**	**Success Criteria**					
		Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
Thinking scientifically	Ideas	☐ Use abstract ideas or models or multiple factors when explaining processes or phenomena	☐ Use abstract ideas or models or more than one step when describing processes or phenomena	☐ Use scientific ideas when describing simple processes or phenomena	☐ Identify differences, similarities or changes related to simple scientific ideas, processes or phenomena	☐ Draw on their observations and ideas to offer answers to questions	☐ Ask questions stimulated by their exploration
	Problems	☐ Identify the strengths and weaknesses of particular models	☐ Explain processes or phenomena, suggest solutions to problems or answer questions by drawing on abstract ideas or models	☐ Use simple models to describe scientific ideas	☐ Respond to ideas given to them to answer questions or suggest solutions to problems. Represent things in the real world using simple physical models	☐ Make comparisons between basic features or components of objects, living things or events	☐ Recognise basic features
	Evidence	☐ Describe some scientific evidence that supports or refutes particular ideas or arguments, including those in development	☐ Recognise scientific questions that do not yet have definitive answers ☐ Identify the use of evidence and creative thinking by scientists in the development of scientific ideas	☐ Identify scientific evidence that is being used to support or refute ideas or arguments	☐ Use straightforward scientific evidence to answer questions, or to support their findings	☐ Sort and group objects, living things or events on the basis of what they have observed ☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) needed to answer a question	☐ Respond to suggestions to identify some evidence (in the form of information, observations or measurements) that has been used to answer a question
	Questions	☐ Explain how new scientific evidence is discussed and interpreted by the scientific community and how this may lead to changes in scientific idea	☐ Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience. ☐ Identify further questions arising from their results.	☐ Use their science experiences to explore ideas and raise different kinds of questions	☐ Raise their own relevant questions about the world around them. ☐ With support, they should identify new questions arising from the data, making predictions for new values within or beyond the data they have collected and finding ways of improving what they have already done.	☐ Explore the world around them and raise their own simple questions	☐ Draw on their experience to help answer questions. Show curiosity about objects, events and people. ☐ Question why things happen
	Predictions		☐ Make predictions using scientific knowledge and understanding	☐ Use their results to make predictions			

Learning outcomes	**Links to teaching**	**Success Criteria**					
		Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
Communicating and collaborating in science	Language	☐ Identify lack of balance in the presentation of information or evidence. Use appropriate scientific conventions and terminology to communicate abstract ideas	☐ Distinguish between opinion and scientific evidence in contexts related to science, and use evidence rather than opinion to support or challenge scientific arguments.	☐ Use appropriate scientific forms of language to communicate scientific ideas, processes or phenomena	☐ Use scientific forms of language when communicating simple scientific ideas, processes or phenomena	☐ Use simple scientific vocabulary to describe their ideas and observations	☐ Use everyday terms to describe simple features or actions of objects, living things or events they observe. Build up vocabulary that reflects the breadth of their experience
	Communicate findings	☐ Choose forms to communicate qualitative or quantitative data appropriate to the data and the purpose of the communication	☐ Decide on the most appropriate formats to present sets of scientific data.	☐ Discuss, communicate and justify their scientific ideas. Report conclusions and causal relationships.	☐ Discuss their ideas and communicate their findings in ways that are appropriate for different audiences, including explanations of results and conclusions	☐ Present their ideas and evidence in appropriate ways	☐ Communicate simple features or components of objects, living things or events they have observed in appropriate forms ☐ Develop their own narratives and explanations by connecting ideas or events.
	Collaborative approaches		☐ Suggest how collaborative approaches to specific experiments or investigations may improve the evidence collected	☐ explanations of degree of trust in results	☐ Identify simple advantages of working together on experiments or investigations	☐ Work together on an experiment or investigation and recognise contributions made by others	☐ Share their own ideas and listen to the ideas of others

Learning outcomes	Links to teaching	Success Criteria					
		Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
Using investigative approaches	Practical exploration	☐ Justify their choices of data collection method and proposed number of observations and measurements	☐ Explain why particular pieces of equipment or information sources are appropriate for the questions or ideas under investigation	☐ Select appropriate equipment or information sources to address specific questions or ideas under investigation	☐ Select equipment or information sources from those provided to address a question or idea under investigation	☐ Identify things to measure or observe that are relevant to the question or idea they are investigating	☐ Respond to prompts by making some simple suggestions about how to find an answer or make observations
	Collecting data	☐ Collect data choosing appropriate ranges, numbers and values for measurements and observations	☐ Repeat sets of observations or measurements where appropriate, selecting suitable ranges and intervals	☐ Make sets of observations or measurements, identifying the ranges and intervals used ☐ Make their own decisions about what observations to make, what measurements to use and how long to make them for	☐ Make some accurate observations or whole number measurements relevant to questions or ideas under investigation ☐ Make systematic and careful observations Help to make decisions about what observations to make, how long to make them for and the type of simple equipment that might be used	☐ Correctly use equipment provided to make observations and measurements ☐ Observe closely using simple equipment with help, observe changes over time	☐ Use their senses and simple equipment to make observations ☐ Engage in open-ended activity ☐ Find ways to solve problems / find new ways to do things / test their ideas
	Risk	☐ Independently recognise a range of familiar risks and take action to control them	☐ Make, and act on, suggestions to control obvious risks to themselves and others	☐ Identify possible risks to themselves and others	☐ Recognise obvious risks when prompted		☐ Take a risk, engage in new experiences and learn by trial and error
	Sorting data			Use and develop keys and other information records to identify, classify and describe living things and identify patterns that might be found in the natural environment	Talk about criteria for grouping, sorting and classifying; and use simple keys	Use simple features to compare living things and, with help, decide how to sort and group them (identifying and classifying)	Develop ideas of grouping, sequences, cause and effect Know about similarities and differences in relation to living things

Learning outcomes	**Links to teaching**	**Success Criteria**					
		Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
Working critically with evidence	Reasoning	☐ Suggest reasons based on scientific knowledge and understanding for any limitations or inconsistencies in evidence collected	☐ Interpret data, recognising obvious inconsistencies	☐ Identify patterns in data	☐ Identify straightforward patterns in observations or data	☐ Say what happened	☐ Respond to prompts to say what happened
	Concluding	☐ Select and manipulate data and information and use them to contribute to conclusions	☐ Provide straightforward explanations for differences in repeated observations or measurements	☐ Draw straightforward conclusions from data presented in various formats	☐ Describe what they have found out, linking cause and effect	☐ Say whether what happened was what they expected, acknowledging any unexpected outcomes	☐ Say what has changed when observing objects, living things or event
	Improvements	☐ Draw conclusions that are consistent with the evidence they have collected and explain them using scientific knowledge and understanding	☐ Draw valid conclusions that utilise more than one piece of supporting evidence ☐ Evaluate the effectiveness of their working methods, making practical suggestions for improving them	☐ Identify scientific evidence they have used in drawing conclusions ☐ Suggest improvements to their working methods, giving reasons	☐ Suggest improvements to their working methods	☐ Respond to prompts to suggest different ways they could have done things	
	Patterns and relationships	☐ Make valid comments on the quality of their data	☐ Interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions	☐ Look for different causal relationships in their data and identify evidence that refutes or supports their ideas	☐ Begin to look for naturally occurring patterns and relationships including changes, similarities and differences. Decide what data to collect to identify them	☐ With guidance, they should begin to notice patterns and relationships	☐ Make links and notice patterns in their experience
	Evaluating	☐ Evaluate data, showing awareness of potential sources of random and systematic error	☐ Present reasoned explanations, including explaining data in relation to predictions and hypotheses.	☐ Identify scientific evidence that has been used to support or refute ideas or arguments	☐ Use the evidence to draw simple conclusions and answer questions	☐ Use their observations and ideas to suggest answers to questions. Talk about what they have found out and how they found it out	☐ Answer how and why questions about their experiences

Learning outcomes	**Links to teaching**	**Success Criteria**					
		Evaluation	**Synthesis**	**Analysis**	**Application**	**Comprehension**	**Knowledge**
	Follow-up and wider research	☐ Distinguish between data and information from primary sources, secondary sources and simulations, and present them in the most appropriate form		☐ Recognise which secondary sources will be most useful to research their ideas and begin to separate opinion from fact	☐ Recognise when and how secondary sources might help them to answer questions that cannot be answered through practical investigations	☐ Ask people questions and use simple secondary sources to find answers	☐ Comments and asks questions about aspects of their familiar world such as the place where they live or the natural world

Appendix 4: Ethical approval

NTU DOCTORAL SCHOOL
NOTTINGHAM TRENT UNIVERSITY

Dawn James
Doctoral School Administrator
Nottingham Trent University
Doctoral School
50 Shakespeare Street, Nottingham
NG1 4FQ
Tel : +0115 84 88154
Email: ntuprofdadmin@ntu.ac.uk

Alison Murphy
31 Huntington Drive
Castle Donnington
DE74 2SR

20 March 2019

Dear Alison

Re: Professional Doctorate Ethical Approval Confirmation

Thank you for submitting an ethical approval application.

I am pleased to confirm that your ethics application has been approved (with conditions)

Student's Name	MURPHY
Supervisor's Name	Elaine Haywood
NTU ID	N0244300
Course	Professional Doctorate – EdD
Committee	Professional Doctorate Research Ethics Committee (PDREC)
Date Approved by Committee	13 March 2019

ACTIONS	**Tick as appropriate**	**Comments**
Approved – no further action	✓	

Should you have any queries please do not hesitate to contact me either by telephone on +44 (0) 115 848 8154 or email ntuprofdadmin@ntu.ac.uk.

Dawn James
Doctoral School Administrator

Appendix 5a: Letter of consent - children

Outdoor Learning Activities

in Partnersip with Nottingham Trent University

You will be exploring Science through outdoor learning activities. This will be run by future teachers at Nottingham Trent University. The sessions will be part of your normal school day and will be recorded through observations, photographs, voice recordings etc to enable us to show off your practical science skills. All of the information will be anonymised and stored safely.

You can talk to …….. or myself if you have any questions about the study.

- I would like to take part in the study on science in the outdoors and I know what the study is about.
- I know what I will be doing.
- I know that I can decide not to continue at any time during the sessions no-one will mind.

Name ……………………………………………………………. Date …………………………………………….

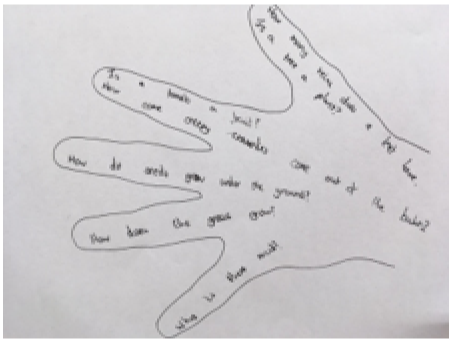
Many thanks

Alison

alison.murphy@ntu.ac.uk

Appendix 5b: Letter of consent – parents

Outdoor Learning Activities in Partnersip with Nottingham Trent University



Your child will be engaging with Science through outdoor learning activities. This will be run in partnership with your child's school and students in their forth year of the BA Education degree who are training to be teachers at Nottingham Trent University. The sessions will be part of the normal school day and will be recorded through observations, photographs, voice recordings etc to exemplify children's practical science skills. All information will be anonymised and stored securely.

You may talk to ……l or myself if you have any questions about the study. The work will comply with research guidelines from the university and will be kept as evidence to support future publications.

We are seeking your consent to include your child in the research:

- The nature and purpose of the research project has been explained to me. understand and agree that my child can take part.
- I understand the purpose of the research project and my child's involvement in it.
- I understand that my child may withdraw from the research project and that this will not affect their status now or in the future.

Signed ……………………………………………………………………………

Print name …………………………………………………………………… **Date** …………………………………

You may wish to look at this website for more information about the approach:

http://www.score-education.org/downloads/practical_work/primary.pdf

Many thanks

Alison

alison.murphy@ntu.ac.uk

Appendix 5c: Letter of consent – head teacher

Nottingham Institute of Education

310 Ada Byron King, Clifton Campus,

Nottingham Trent University,

Nottingham, NG11 8NS

Tel: +44 (0)1158488920

Dear [Name],

I am writing for your permission to conduct some research with your school in the Autumn term. I am a doctoral research student at Nottingham Trent University, supervised by Dr [redacted] [redacted]@ntu.ac.uk and Dr [redacted] [redacted]@ntu.ac.uk. In my research project, *How can teachers most effectively support progression in primary science through the outdoors?*, I intend to explore and make sense of the learning which is occurring. I am interested in documenting changes and capturing examples to exemplify the 'science skills' being used in context by the children. It is hoped that this may give greater credibility to the learning in context and could provide better evidence of progression in learning.

As part of their course, I intend to help the student teachers to plan for quality learning as well as understand the learning that is occurring. By participating in the research, your school will be contributing to a project that intends to deepen our understanding of practical scientific learning, with the potential to develop ways of improving attainment for primary aged children in the future.

The commitment from the school will be to enable formative assessment data collection to occur, over time, in line with the children's usual learning. The students are likely to audio-record children engaged in learning, observe and take notes, ask them questions and collect examples of the children's written recording where appropriate. The evidence will be uploaded to the NOW learning room which is username and password protected.

All participants, including children, students, staff and the school, will be made anonymous in all research reports. The data collected will be kept strictly confidential, available only to my supervisors and myself, and not used other than specified without the further consent of all involved being obtained. All recordings will be destroyed at the end of the research period, and kept in locked conditions until then.

The university has strict ethical procedures on conducting ethical research with teachers and young people, consistent with current British Educational Research Association guidelines https://www.bera.ac.uk/researchers-resources/publications/ethical-guidelines-for-educational-research-2018. I will inform the participants, along with children's parents and guardians, about the research. I will provide them with the opportunity to refuse to participate in the data collection and to withdraw their involvement before the data is uploaded onto NOW.

- I understand that my school's participation in this study is entirely voluntary.
- I understand that the child participants will be free to withdraw themselves from this study at any time on the day and without giving a reason.
- I understand that that the identity of children will be treated confidentially and that all information will be stored anonymously and securely. All information appearing in the final report will be anonymous. All participants will have the option of withdrawing their data from the study, up to the point that the data is uploaded onto NOW.
- I understand that the work will comply with the research guidelines from the university and will be kept as evidence to support future publications.
- I understand that I am free to discuss any questions or comments I might have with the researcher or the supervisors.
- I also understand that at the end of the study I will be provided with additional information and feedback about the findings of the study.

I **do/do not** (*delete as appropriate*) consent to ……………………………………… school's participation in this study.

Signed …………………………………………………………………………………

Print name ……………………………………………………………………… **Date** …………………………………

If you are happy to take part in the study and need more information about what is involved, please feel free to contact me.

Thank you for your time and attention. I look forward to hearing from you.

Yours sincerely,

Alison Murphy alison.murphy@ntu.ac.uk

Appendix 5d: Letter of consent – trainee

Participant consent form

Research title: Outdoor Learning Workshops in Partnersip with NTU

The purpose of the project is to make sense of the scientific learning that is occurring within primary schools. I am interested in documenting changes and capturing examples of the children's learning to exemplify the science skills being used in the outdoor context.

This will build upon the content of the Primary 5-11 strand module PRBA33202. There will be an initial session led by the researcher to introduce the concept of 'assessing practical science'. Following this, you will be both a participant and co-researcher, developing the approach of assessing children 'over time in your own setting' and recording sessions for analysis in partnership with the researcher.

Within the sessions you will be recording the learning through observations, photographs, voice recordings etc to exemplify children's practical science skills. All information will be anonymised and stored securely.

The work will comply with research guidelines from the university and will be kept as evidence to support future publications.

I am seeking your consent to include your evidence in the research:

- The nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project until the point when the data is uploaded and that this will not affect my status now or in the future.
- I understand that while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
- I understand that data that I collect needs to be stored securely on a password protected device and can be added to my PDF.
- The data needs to be destroyed once it has been uploaded onto NOW.
- I understand that I may contact the researcher, if I require further information about the research.

Signed .... (research participant)

Print name .... **Date** ....

Many thanks

Alison Murphy alison.murphy@ntu.ac.uk

Appendix 6: Pilot study focus group interview schedule

Pilot Study Focus Group Interview Schedule (Trainees)

Q 1: What interests you about working with children in an outdoor context?

Q2: How did this differ to teaching in the classroom?

Q3: Can you define skills versus knowledge & understanding?

Q4: What didn't you realise before that you now know?

Q5: In order to identify progression: how do you know what the children have learnt?

Q6: What evidence did you collect?

Q7: What qualitative comments were collected?

Q8 Articulate your evidence – what does it show?

Q9: What could you have collected?

Q10: What is the relevance? How is it useful? How would this have aided your understanding of the learning?

Q11: What would you have collected for a Maths/English unit of learning?

Q12: How could you make the evidence collection more reliable?

Q13: What could I have done to help you?

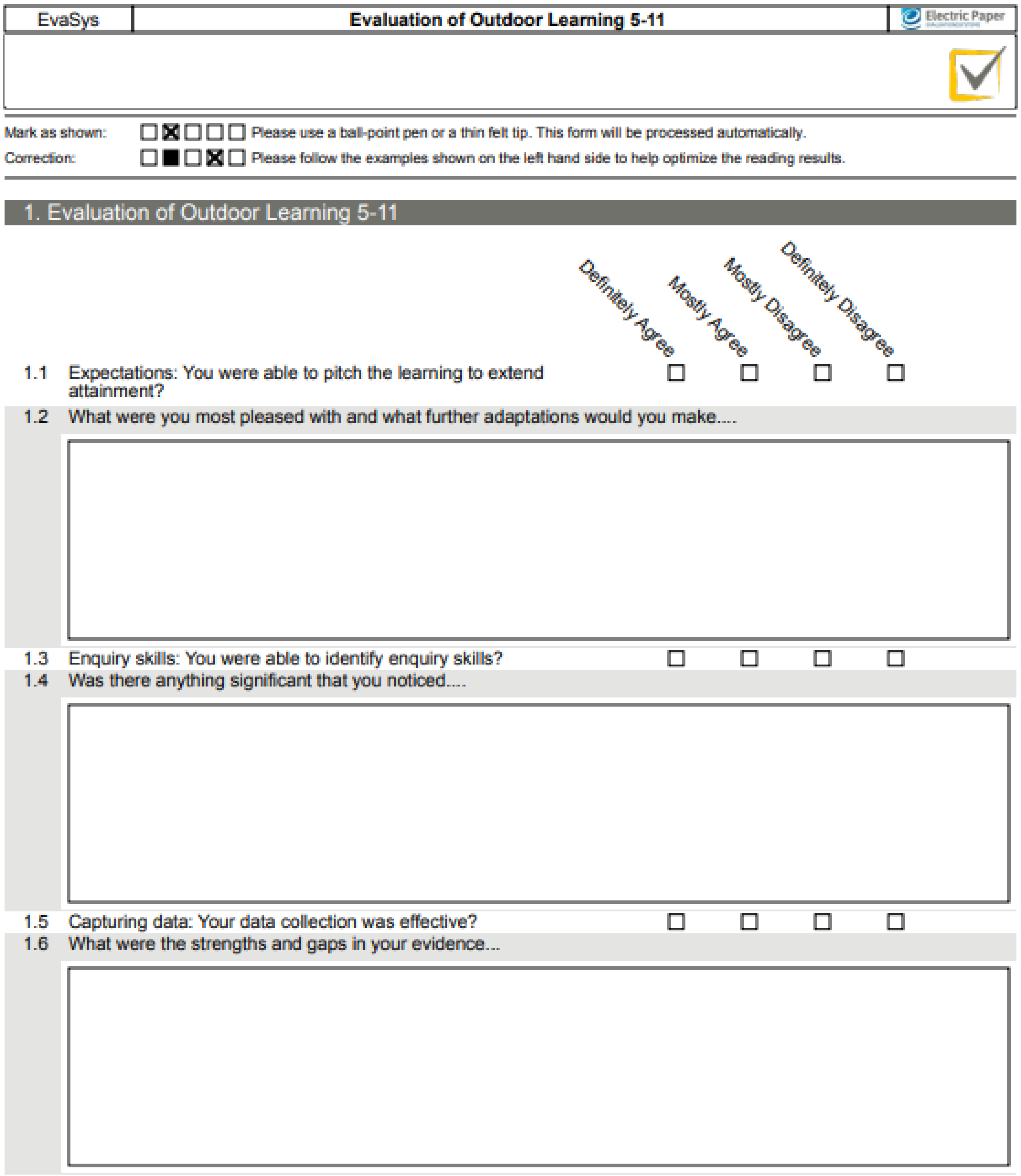
Q14: What support could have been provided to help you? If something could have been modelled for you – what would it have been?

Q15: How can you more accurately capture higher order learning? Year 5/6?

Q16: How can you extend the learners? How can you differentiate?

Q17: Make links to talk project in Y3.

Appendix 7: EVASYS questionnaire example

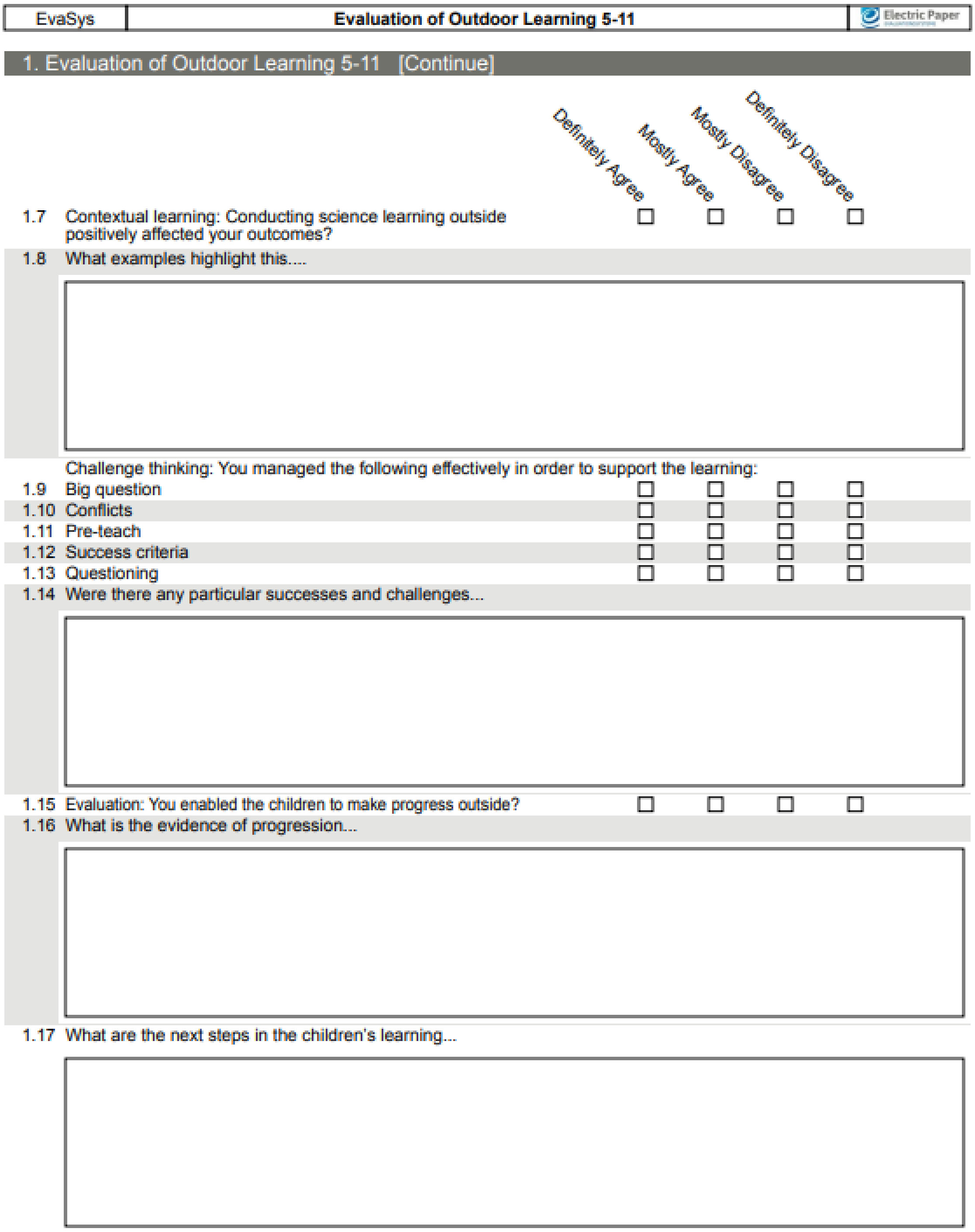


EvaSys **Evaluation of Outdoor Learning 5-11** Electric Paper

Mark as shown: ☐☒☐☐☐ Please use a ball-point pen or a thin felt tip. This form will be processed automatically.
Correction: ☐■☐☒☐ Please follow the examples shown on the left hand side to help optimize the reading results.

1. Evaluation of Outdoor Learning 5-11

		Definitely Agree	Mostly Agree	Mostly Disagree	Definitely Disagree
1.1	Expectations: You were able to pitch the learning to extend attainment?	☐	☐	☐	☐
1.2	What were you most pleased with and what further adaptations would you make....				
1.3	Enquiry skills: You were able to identify enquiry skills?	☐	☐	☐	☐
1.4	Was there anything significant that you noticed....				
1.5	Capturing data: Your data collection was effective?	☐	☐	☐	☐
1.6	What were the strengths and gaps in your evidence...				



EvaSys | **Evaluation of Outdoor Learning 5-11** | Electric Paper

1. Evaluation of Outdoor Learning 5-11 [Continue]

		Definitely Agree	Mostly Agree	Mostly Disagree	Definitely Disagree
1.7	Contextual learning: Conducting science learning outside positively affected your outcomes?	☐	☐	☐	☐

1.8 What examples highlight this....

Challenge thinking: You managed the following effectively in order to support the learning:

1.9	Big question	☐	☐	☐	☐
1.10	Conflicts	☐	☐	☐	☐
1.11	Pre-teach	☐	☐	☐	☐
1.12	Success criteria	☐	☐	☐	☐
1.13	Questioning	☐	☐	☐	☐

1.14 Were there any particular successes and challenges...

1.15	Evaluation: You enabled the children to make progress outside?	☐	☐	☐	☐

1.16 What is the evidence of progression...

1.17 What are the next steps in the children's learning...

Appendix 8: Pilot evidence

Key:

- Handwritten extracts from the questionnaire
- Black text from focus group 1
- Green text from focus group 2.

Appendix 8a: Pilot evidence: the value of outdoor science learning

- The questionnaires highlighted the value of outdoor learning in relation to science.
- The trainees commented about the children's enthusiasm, engagement, recall, willingness to learn and share, practical application, confidence, ideas, curiosity and learning in context.

Enthusiasm

Children were enthusiastic and using their surroundings to discuss frog adaptions, life cycle, etc. Allowed children to recreate pond with real ~~to~~ pond elements

- Children becoming excited about being outdoors and coming up with explanations from their observations.

Engagement

Children's engagement was high with natural questioning and application of knowledge.

Childrens enthusiasm and engagement with the lesson and the continuous talk and questioning to promote deeper thinking throughout.

Children were really engaged with the activity and asked lots of questions about trees & seed dispersal.

Children were engaged in first hand learning.

Seeing, holding exploring for seeds and their environments engaged children.

Chd were highly engaged & because of this wanted to learn more.

Children were so engaged, they didn't want the lesson to end.

E Children were more engaged and motivated

Engaged and recall

How interested & engaged they were in the lesson.

They could recall facts from pre-teach.

Willing to learn and share

The children were willing to learn. Children were able to share ideas and correct their own misunderstandings through enquiry and the outdoor exploration as a group

Practical application

The childrens ability to apply what they have been taught into new scenarios. (photosynthesis into pond life)

Their observation skills and being able to relate what they have learnt to the outdoors.

practical, hands-on can apply their learning better.

able to identify features & apply knowledge

Positively affected their ability to apply learning to novel scenarios.

Confidence

Children were confident at the start of the activity but clearly learnt new knowledge from looking for the seeds outside.

E. We used pooters to collect insects. Quite scary to do this and I was impressed with them. They were fully into it.

Ideas

Clear observations that led to children hypothesising ideas as to why the seeds were like they were. E.g why there were so many sycamore seeds and what features enable them to disperse.

Curiosity

The children had lots of questions about conkers and seeds and what could be inside them

-Children wondering why not all of the seeds that were on the ground become a plant.

E. The curiosity of it.

Learning in context

Children could clearly see how the seed dispersal techniques we looked at outside linked to the life cycle of a seed.

-Children putting their learning into context such as what a plant needed to grow.

The children were able to actively see it and observe it taking place along with being able to seek out their own seeds

W; I was cynical about outdoor learning. However, I could see how it developed skills, gave them a better understanding about lots of things, like climate change. It is so much better than just watching videos in the classroom, actually going out and seeing it and learning first hand.

T. We compared two ponds and discussed the processes, with one making more oxygen. The algal water was really clear and discussed the differences. They were surprised at the results. Two ponds one had lots of algae and the other didn't. More interested in outside.

Appendix 8b: Pilot evidence: the practicalities of collecting evidence of learning

- The trainees found collecting evidence of learning challenging to achieve at the same time as managing the learning.

Recording

we had good images that capture the learning but was hard to record what they all said

Photos allowed us to capture in the moment
We noted all the children's questions.

Yes the strengths was we took photographic evidence, notes, and examples of the children's work. We were using formative Assessment

Detailed observations were made however writing them down outdoors proved difficult.

H For reliability you would want to write it down word for word. I should have recorded it. You could see it was reliable from this child’s work.

G; Focused on teaching, don’t have time to collect and write down and after the activity it is easy to forget.

E; Focus on evidence that sometimes you can miss valuable questioning.

G; Post it notes work, easy to collect the data. Show them an example first; modelling helps. They have the knowledge but can’t see it from the evidence you have documented.

G; Important they are still learning, and the time isn’t spent on you trying to get evidence!

T. Difficult to write it down as well as facilitating the discussion.

H Could have recorded what they were saying. Then we could have been able to note the language being used.

G; We collected post its. We thought about the use of a voice recorder but changed our mind as we didn’t think that it would be a reliable source. Wind could affect the recording.

E; Writing sometimes put the children off, makes them not feel like you are listening to them whilst they are talking. When you are recording what they say all the time, it actually makes some children stop sharing. This is an area to get more experience on.

E; Recorded what they said, more discussion and address misconceptions.

E; Writing down what they are saying etc was easier as the groups were smaller and not just one adult teaching. If one missed something, the other picked it up. Annotated it on their work at the time they said it. As the children wrote things down, this backs up their knowledge, as opposed to me writing down, this is what they said.

Writing can slow you down and you can miss what is happening around you.

Weather conditions and noise can affect using technology to record.

C. Could not gather much evidence as we were moving around so much

E. Discussions with each of the pupils, I wrote this down. Used question prompts.

H Drawings / sketches. Observation notes and photographs.

E. Transcripts of what they have said.

W; Hard to assess to benefit children. In the moment learning, not always in a position to record. Could do a fact file or make a tool for the children to document what they have learnt. Can assess whilst reasoning. I agree, I wouldn't feel confident with using a voice recorder outside.

Amount of learning available to collect

However, they were saying so much & with the exploring outside, we missed a few.

strengths
→ lots of q's asked by the chn + good ones too

gaps
→ Hard to record the answers / questions because it was very hands on .

Would have been better to voice record the session so that we could capture everything the children said

Routines

Sometimes forgot to write / take pics as engaged in activity.

The booklets that the children completed after the session

Appendix 8c: Pilot evidence: managing child led learning

- The trainees commented on finding a balance between the level of scaffolding and child-led learning within the outdoor sessions.

Examples where child-led learning was enabled

children were asking questions and trying to find the answers for themselves.

Effective questioning of how various seeds may be dispersed.

It was child-led so children could express their understanding through drawings, diagrams or writing

H. Way more beneficial than a talk activity because they were more interested. Experience hands on. Lots of independence.

E; taking the children outside it seems like there is more opportunity for independent learning than there is in the classroom. In the classroom, they are given instructions, not only on the work they do but how the work is to be shown etc. They have more free range, there are still boundaries and expectations, but they experiment and dig deep, you have to trust them more. They tend to not take advantage as they like being outside and do not want to lose the opportunity to repeat it.

M; Using the mastery approach, giving them opportunity to independently control learning. Can be done at their own pace and enjoyment. Share with each other to build on rather than teacher led.

Recognising the child's voice.

Every child engaged throughout all of the activities + had lots of things to say.

C. In the end we stood back and just let it….

Suggested it was too child-led

children lacked focus sometimes

we could have created more conflicts.

E; if you leave them to it, they might not push themselves or have the confidence to extend themselves. Finding balance, I wouldn't want to push top much and put them off, so it would be a judgement call.

Suggested it was too teacher led

Have more time in the environment allowing children to explore & discover for themselves.

-Challenge to organise the children to look at a specific thing

M; We did a plenary, keywords were used. The use of question cards. Before the activity we did ask the children questions about the what they think. After we asked the same questions and they were able to answer and make it more scientific. Also, correct errors in their knowledge.

The teacher requirements to facilitate

E. You have to plan in advance.

T The plan can change.

Appendix 8d: Pilot evidence: personalising learning

- The trainees found it challenging to personalise the learning without a knowledge of the children's needs and their prior learning.

Difficult to get the whole picture of a childs understanding.

-Accommodating the unknown range of attainments

E; I underestimated the children. Didn't think they would have the ideas. Justification and reasoning were a lot higher than I expected. For example; we did a mini beast activity and the children spoke about camouflage and how it would be good so they can hide from people who want to eat them.

I have learnt not to assume and restrict them.

T Harder when you don't know the pupils

Appendix 8e: Pilot evidence: understanding the science expectations

- When the trainees understood the science expectations, the learning was more purposeful.

They were able to see different types of mushrooms in their natural environments and also how different fruit and vegetables grew in comparison

Children ability to identify Plant Parts in the environment with excitement.

we gave the children the same sheet at the end as they had at the Start about what we learnt outside & they massively improved

Children evidence understanding of knowledge and application with reasoning.

the children could apply knowledge of plants to other plants they encounterd

Moving into habitats, food chains. use knowledge to generalise life cycles.

The childrens observation skills and their ability to analyse.

Children were pointing out similarities and differences.

Most pleased with childrens scientific reasoning for adaptations on minibeasts (terminology)

- create your own minibeast generated good discussion & questioning & reasoning could predict +find minibeasts in the outdoors environment, apply knowledge

H Where have all of the birds gone. Straight away a boy could talk about migration. When he was doing his drawing, he was challenged to explain why they used different materials. He used the word infrastructure to protect the egg. The others were not able to do this. He could justify this answer.

E; Planning examples; perhaps a template or a previous planning sheet that had been completed. More ideas of different activities and lesson plan templates completed ones.

H Pre-teach was an egg on the ground and asked why it should be there. Immediately said birds' nests and could identify some, pigeons, robins and penguins. They could link protection and differences with different birds, such as protection and the reasons why. Why the egg might have been on the floor? The progression was that they could convince us that it was a good nest once they had built it. Stones around would stop it blowing away.

Use of questioning and talk

They were discussing and asking further questions.

Talk and questioning to share ideas and address misconceptions with their peers and student teachers

Chn used questioning to address misconceptions Then used group talk to share ideas ~~to~~ + to overcome barriers.

I noticed how the children were scaffolding each other's learning through group discussion and Shared Sustained thinking.

H They were all vocal and willing to speak.

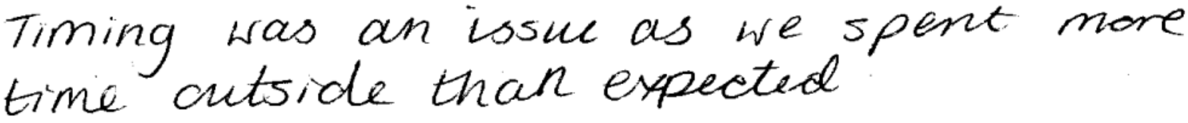
E. Questioning why things were where they were.

H. My children bounced ideas off each other.

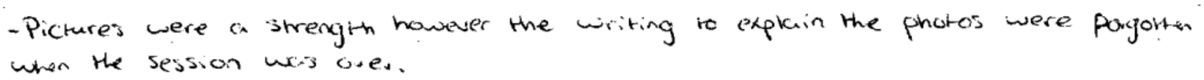
T The children's language improved. Creating oxygen with the fountain. Their language developed over the two hours.

Appendix 8f: Pilot evidence: opportunities for reflection

- The trainees realised that the timing of the session needed to allow for reflection on the learning to provide more opportunities to demonstrate critical thinking.



Timing was an issue as we spent more time outside than expected



-Pictures were a strength however the writing to explain the photos were forgotten when the session was over.

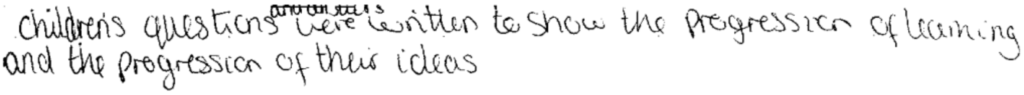
E; I would have liked a follow up with the children, what they learned after going back to the classroom and being asked by their teacher.

W; A post session would have been good. Where we could evaluate, share ideas and what we found.

E; Factor time in lesson to annotate and write evidence down. Didn't plan enough based on the ability of the children, equally I don't know where I would have gone from there with it to extend it.

Appendix 8g: Pilot evidence: using the matrix

- The trainees supported their assessments using the matrix but found it challenging to assess so many aspects within the learning.



children's questions annotations were written to show the progression of learning and the progression of their ideas

children starting to ask own questions

E. Collecting the data. Examples of the evidence type. I need more support with that.

G; Always different, hard to put into categories as its open ended.

Appendix 9: Main study interview schedule

Main Study Interview Schedule (Trainees)

EdD title: How can teachers most effectively support children's learning in primary science, using the outdoors?

Questions: Semi-structured with follow-up questions – some additional ones may be emailed out if something comes up as a result of a discussion.

Please use your booklets and field notes from the outdoor science sessions to evidence the learning that you share with me in the teams interview.

I hope to record the interview for transcription but please feel free to notify me if you would prefer the conversation to not be recorded.

Q1) Looking back at the interviews in the pilot, how has your thinking changed?

Q2) What do the booklets (or further learning evidence) show you?

Q3) What could you identify that might be evidence of thinking scientifically?

Q4) How do you feel the children's questions changed over time?

Q5) Is there anything you still don't know?

Q6) Has your work on outdoor learning in science inspired you to use it in your future practice?

Q7) With your new knowledge, what are your recommendations for non-specialist teachers? What are your recommendations for the course and my teaching?

Appendix 10: Data management plan

NTU Data Management Plan Template

Full name:	**Alison Murphy**
ORCID ID:	**0000-0003-4308-0701**
Provisional project title:	**How can teachers most effectively support progression in primary science through the outdoors?**
Project start date: January 2018	Project end date: January 2022
Project context: I hope to make sense of the scientific learning occurring within primary schools and am interested in documenting changes and capturing examples to exemplify the science skills being used in the outdoor context by the children.	

1. Defining your data

a) Describe your data and how you will be working with it

Qualitative data: photographs, videos, transcripts from voice recordings, children's writing/drawings.

Anonymised personal data on participants and their actions.

b) What formats and software will you use?

Word doc, PDF, audio and image/video files

c) How much data do you expect to generate?

6 undergraduates, collecting info on 6 children over a 12 month period.

The pilot may also generate approx. **1 GB** of data.

Using an average med/hi- resolution photo is around 5 MB, so 1000 x 5MB = **5 GB**

An average 30 mins spoken audio (MP3 compressed) 5MB, so 6 Children x 6 times X 6 terms x 5MB, = **1 GB**

Plus word, PDF files, etc**. = 10 GB**

If I needed to collect video or uncompressed audio **50 GB** might be more appropriate.

2. Compliance & data ownership

a) Is some/all data subject to any institutional, legal, ethical, or commercial conditions?

Institutional RDM policy – register, deposit, share. See 3,4,5

BERA guidelines – identity and confidentiality - informed consent, anonymisation techniques and protecting data.

b) What do you need to do to comply with these obligations?

Participant information and consent forms.

The NOW drop box or Microsoft TEAMs is password protected and will be used for uploading examples of the learning. This will remain there until the end of their course (18 months). The data will be transferred to the NTU data store for security and protection. External collaborators will be able to access this data via a subfolder containing anonymised data. If data needs to be transferred between the principle investigator and or partnership schools, it will be transferred via NTU Zendto.

The evidence that underpins my findings will deposited and preserved for 10 years and shared with researchers for future reuse upon request. Personal data will not be disclosed to third parties. Informed consent will be obtained for this from participants.

The point at which the data cannot be withdrawn is after anonymisation and after the date it is uploaded onto NOW. The analysis and evaluation of the data may involve sharing data with the students (and partnership school staff) in the role of co-researchers. Dissemination will be through meetings, research conferences, publication and taught content on the BA course.

c) Who owns the data?
Attributed to me but governed by NTU institution.
There are no conditions attached as this is not data for a third party.

3. Working with your data

a) Where will you store your data?
NOW drop box and discussion groups which are secured by NTU username and password
NTU data store
Zendto for data transfer.
Student storage – password protected and they will be advised to store data securely in their placement file.
Files on data collection devices will be deleted at the point of uploading.

b) How will you back-up your data?
On a password protected USB stick

c) Who else is allowed to access this data during the project?
Supervisors, contributors: partnership schools, staff, parents, children and students

d) How will you organise your data folders?
Files for: School, student, child anonymous coding, data collection method. To enable ease of withdrawal if necessary. Date order.

e) How will you name your files?
Location, student, child, date, collecting method.

f) How will you manage different versions of your files?
Version 1 affixed to end

g) How will you ensure your data is understandable to others?
Inventory of what has been collected by whom and when.

4. Archiving your data

a) What data should be kept, or destroyed, after the end of your project?
Source data; data collected, created, or held elsewhere that the research has used. Raw data will be deleted once the project is assessed as passing.

Assembled datasets; data extracted or derived from the source data - will be archived.

Referenced data; data that takes the analysis further or enables further conclusions to be drawn e.g. supplementary 'supplementary material' – this will be archived.

b) Where will you archive your data?
NTU data archive

c) When will you archive your data?
Deposit prior to viva.
Data embargoed until thesis is released.

d) How long will the data be archived for?
Data from the study will be kept for 10 years.

5. Sharing your data

a) How will others learn that your data exists?

After depositing my project data, I will register my data with NTU by submitting a PGR Data Registry Form. A metadata record for my research data will be created in NTU IRep. This record will offer a full description of my data, as well as linking directly to the record of my thesis. The thesis record will also link to the dataset metadata record so that people who locate my thesis will also be directed to its underpinning data.
Conference sharing and publication of findings.

b) Which data will be accessible to others?
See section 2

c) Who will you share your data with and under what conditions?
Bone fide researchers will be granted access to the data in the NTU Data Archive upon request under a CC-BY-NC 4.0 licence

d) How will you share your data?
Conference and article publication
Increase the impact by citing the data and grow the potential for outputs.

6. Implementing your DMP

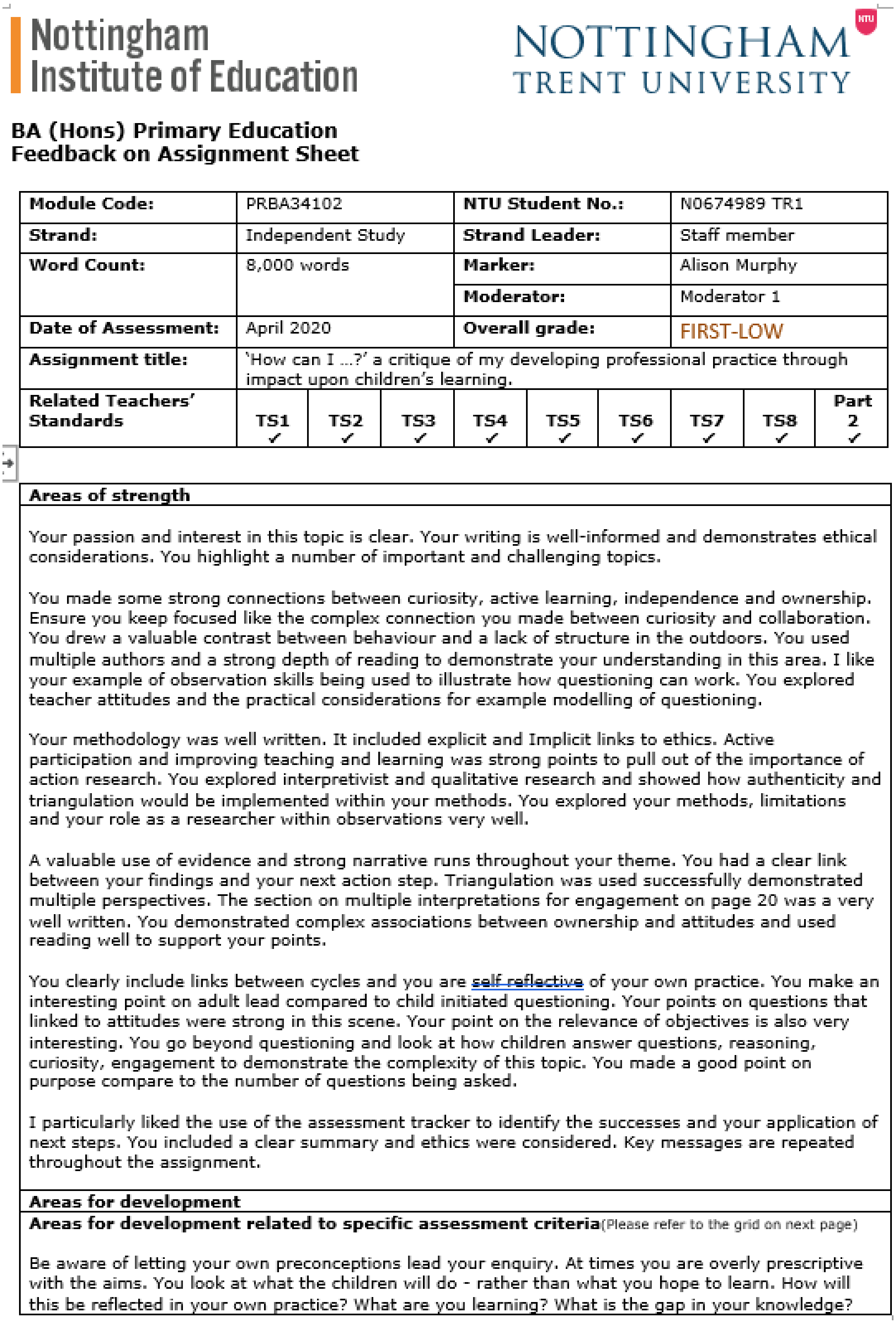
a) How often will this plan be reviewed and updated?
Supervisory meetings yearly as necessary to consider actions, problems, changes.

b) What actions have you identified from the rest of this plan?

- Data storage organised (NTU data store)
- Ethical clearance passed and consent forms completed
- Drop box/discussion groups set up
- Anonymisation ensured for children including students
- File naming consistent following structure.
- USB password protected
- Ensure data is deleted when uploaded and students manage data safely
- Learn how to use Zendto
- Complete PGR Data Registry Form.
- Complete IRep profile.
- Identify potential conferences and journals for publication.
- Share with supervisors
- Access organised for data sharing – including an accessible sub-folder

c) What support/ information do you need to complete these actions?
Training from Data Management Officer received on Feb 2019.
NTU Research Data Management Officer ongoing advice.
Access permitted for data sharing.

Appendix 11a: TR1 FASh with moderation of grade



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BA (Hons) Primary Education
Feedback on Assignment Sheet

Module Code:	PRBA34102	**NTU Student No.:**	N0674989 TR1
Strand:	Independent Study	**Strand Leader:**	Staff member
Word Count:	8,000 words	**Marker:**	Alison Murphy
		Moderator:	Moderator 1
Date of Assessment:	April 2020	**Overall grade:**	FIRST-LOW
Assignment title:	'How can I …?' a critique of my developing professional practice through impact upon children's learning.		

Related Teachers' Standards	**TS1** ✓	**TS2** ✓	**TS3** ✓	**TS4** ✓	**TS5** ✓	**TS6** ✓	**TS7** ✓	**TS8** ✓	**Part 2** ✓

Areas of strength

Your passion and interest in this topic is clear. Your writing is well-informed and demonstrates ethical considerations. You highlight a number of important and challenging topics.

You made some strong connections between curiosity, active learning, independence and ownership. Ensure you keep focused like the complex connection you made between curiosity and collaboration. You drew a valuable contrast between behaviour and a lack of structure in the outdoors. You used multiple authors and a strong depth of reading to demonstrate your understanding in this area. I like your example of observation skills being used to illustrate how questioning can work. You explored teacher attitudes and the practical considerations for example modelling of questioning.

Your methodology was well written. It included explicit and Implicit links to ethics. Active participation and improving teaching and learning was strong points to pull out of the importance of action research. You explored interpretivist and qualitative research and showed how authenticity and triangulation would be implemented within your methods. You explored your methods, limitations and your role as a researcher within observations very well.

A valuable use of evidence and strong narrative runs throughout your theme. You had a clear link between your findings and your next action step. Triangulation was used successfully demonstrated multiple perspectives. The section on multiple interpretations for engagement on page 20 was a very well written. You demonstrated complex associations between ownership and attitudes and used reading well to support your points.

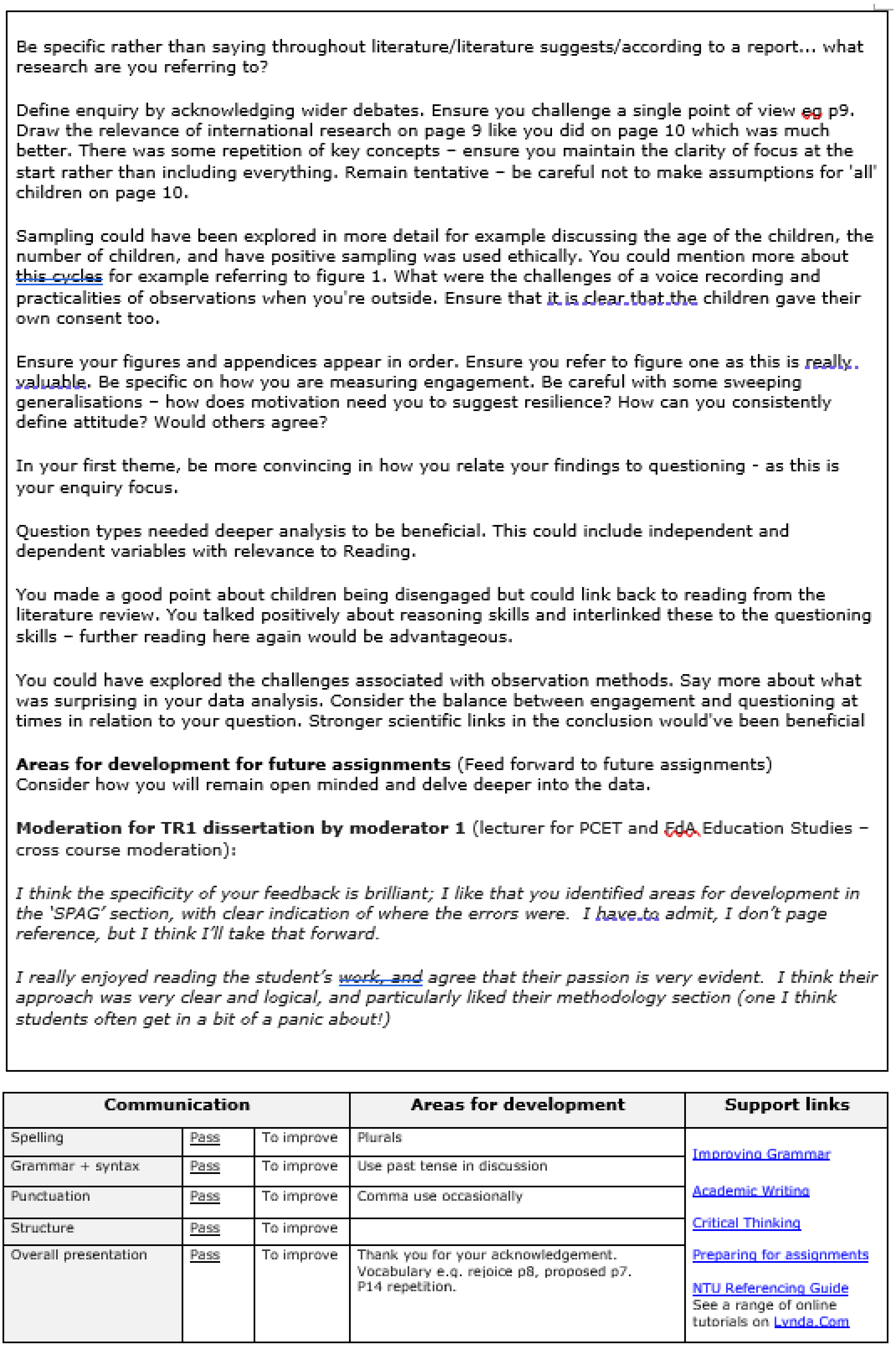
You clearly include links between cycles and you are self reflective of your own practice. You make an interesting point on adult lead compared to child initiated questioning. Your points on questions that linked to attitudes were strong in this scene. Your point on the relevance of objectives is also very interesting. You go beyond questioning and look at how children answer questions, reasoning, curiosity, engagement to demonstrate the complexity of this topic. You made a good point on purpose compare to the number of questions being asked.

I particularly liked the use of the assessment tracker to identify the successes and your application of next steps. You included a clear summary and ethics were considered. Key messages are repeated throughout the assignment.

Areas for development

Areas for development related to specific assessment criteria(Please refer to the grid on next page)

Be aware of letting your own preconceptions lead your enquiry. At times you are overly prescriptive with the aims. You look at what the children will do - rather than what you hope to learn. How will this be reflected in your own practice? What are you learning? What is the gap in your knowledge?



Be specific rather than saying throughout literature/literature suggests/according to a report... what research are you referring to?

Define enquiry by acknowledging wider debates. Ensure you challenge a single point of view eg p9. Draw the relevance of international research on page 9 like you did on page 10 which was much better. There was some repetition of key concepts – ensure you maintain the clarity of focus at the start rather than including everything. Remain tentative – be careful not to make assumptions for 'all' children on page 10.

Sampling could have been explored in more detail for example discussing the age of the children, the number of children, and have positive sampling was used ethically. You could mention more about this cycles for example referring to figure 1. What were the challenges of a voice recording and practicalities of observations when you're outside. Ensure that it is clear that the children gave their own consent too.

Ensure your figures and appendices appear in order. Ensure you refer to figure one as this is really valuable. Be specific on how you are measuring engagement. Be careful with some sweeping generalisations – how does motivation need you to suggest resilience? How can you consistently define attitude? Would others agree?

In your first theme, be more convincing in how you relate your findings to questioning - as this is your enquiry focus.

Question types needed deeper analysis to be beneficial. This could include independent and dependent variables with relevance to Reading.

You made a good point about children being disengaged but could link back to reading from the literature review. You talked positively about reasoning skills and interlinked these to the questioning skills – further reading here again would be advantageous.

You could have explored the challenges associated with observation methods. Say more about what was surprising in your data analysis. Consider the balance between engagement and questioning at times in relation to your question. Stronger scientific links in the conclusion would've been beneficial

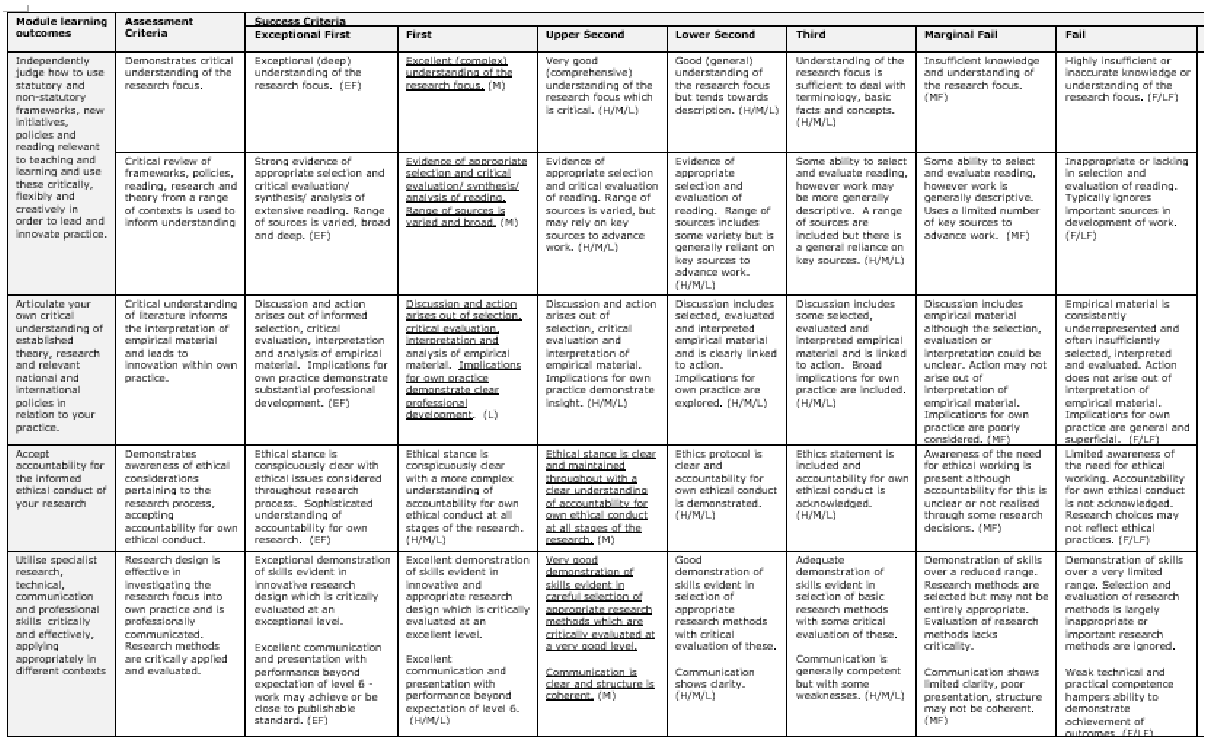
Areas for development for future assignments (Feed forward to future assignments)
Consider how you will remain open minded and delve deeper into the data.

Moderation for TR1 dissertation by moderator 1 (lecturer for PCET and FdA Education Studies – cross course moderation):

I think the specificity of your feedback is brilliant; I like that you identified areas for development in the 'SPAG' section, with clear indication of where the errors were. I have to admit, I don't page reference, but I think I'll take that forward.

I really enjoyed reading the student's work, and agree that their passion is very evident. I think their approach was very clear and logical, and particularly liked their methodology section (one I think students often get in a bit of a panic about!)

Communication			Areas for development	Support links
Spelling	Pass	To improve	Plurals	Improving Grammar Academic Writing Critical Thinking Preparing for assignments NTU Referencing Guide See a range of online tutorials on Lynda.Com
Grammar + syntax	Pass	To improve	Use past tense in discussion	
Punctuation	Pass	To improve	Comma use occasionally	
Structure	Pass	To improve		
Overall presentation	Pass	To improve	Thank you for your acknowledgement. Vocabulary e.g. rejoice p8, proposed p7. P14 repetition.	



Module learning outcomes	Assessment Criteria	Success Criteria						
		Exceptional First	First	Upper Second	Lower Second	Third	Marginal Fail	Fail
Independently judge how to use statutory and non-statutory frameworks, new initiatives, policies and reading relevant to teaching and learning and use these critically, flexibly and creatively in order to lead and innovate practice.	Demonstrates critical understanding of the research focus.	Exceptional (deep) understanding of the research focus. (EF)	Excellent (complex) understanding of the research focus. (M)	Very good (comprehensive) understanding of the research focus which is critical. (H/M/L)	Good (general) understanding of the research focus but tends towards description. (H/M/L)	Understanding of the research focus is sufficient to deal with terminology, basic facts and concepts. (H/M/L)	Insufficient knowledge and understanding of the research focus. (MF)	Highly insufficient or inaccurate knowledge or understanding of the research focus. (F/LF)
	Critical review of frameworks, policies, reading, research and theory from a range of contexts is used to inform understanding	Strong evidence of appropriate selection and critical evaluation/ synthesis/ analysis of extensive reading. Range of sources is varied, broad and deep. (EF)	Evidence of appropriate selection and critical evaluation/ synthesis/ analysis of reading. Range of sources is varied and broad. (M)	Evidence of appropriate selection and critical evaluation of reading. Range of sources is varied, but may rely on key sources to advance work. (H/M/L)	Evidence of appropriate selection and evaluation of reading. Range of sources includes some variety but is generally reliant on key sources to advance work. (H/M/L)	Some ability to select and evaluate reading, however work may be more generally descriptive. A range of sources are included but there is a general reliance on key sources. (H/M/L)	Some ability to select and evaluate reading, however work is generally descriptive. Uses a limited number of key sources to advance work. (MF)	Inappropriate or lacking in selection and evaluation of reading. Typically ignores important sources in development of work. (F/LF)
Articulate your own critical understanding of established theory, research and relevant national and international policies in relation to your practice.	Critical understanding of literature informs the interpretation of empirical material and leads to innovation within own practice.	Discussion and action arises out of informed selection, critical evaluation, interpretation and analysis of empirical material. Implications for own practice demonstrate substantial professional development. (EF)	Discussion and action arises out of selection, critical evaluation, interpretation and analysis of empirical material. Implications for own practice demonstrate clear professional development. (L)	Discussion and action arises out of selection, critical evaluation and interpretation of empirical material. Implications for own practice demonstrate insight. (H/M/L)	Discussion includes selected, evaluated and interpreted empirical material and is clearly linked to action. Implications for own practice are explored. (H/M/L)	Discussion includes some selected, evaluated and interpreted empirical material and is linked to action. Broad implications for own practice are included. (H/M/L)	Discussion includes empirical material although the selection, evaluation or interpretation could be unclear. Action may not arise out of interpretation of empirical material. Implications for own practice are poorly considered. (MF)	Empirical material is consistently underrepresented and often insufficiently selected, interpreted and evaluated. Action does not arise out of interpretation of empirical material. Implications for own practice are general and superficial. (F/LF)
Accept accountability for the informed ethical conduct of your research	Demonstrates awareness of ethical considerations pertaining to the research process, accepting accountability for own ethical conduct.	Ethical stance is conspicuously clear with ethical issues considered throughout research process. Sophisticated understanding of accountability for own research. (EF)	Ethical stance is conspicuously clear with a more complex understanding of accountability for own ethical conduct at all stages of the research. (H/M/L)	Ethical stance is clear and maintained throughout with a clear understanding of accountability for own ethical conduct at all stages of the research. (M)	Ethics protocol is clear and accountability for own ethical conduct is demonstrated. (H/M/L)	Ethics statement is included and accountability for own ethical conduct is acknowledged. (H/M/L)	Awareness of the need for ethical working is present although accountability for this is unclear or not realised through some research decisions. (MF)	Limited awareness of the need for ethical working. Accountability for own ethical conduct is not acknowledged. Research choices may not reflect ethical practices. (F/LF)
Utilise specialist research, technical, communication and professional skills critically and effectively, applying appropriately in different contexts	Research design is effective in investigating the research focus into own practice and is professionally communicated. Research methods are critically applied and evaluated.	Exceptional demonstration of skills evident in innovative research design which is critically evaluated at an exceptional level. Excellent communication and presentation with performance beyond expectation of level 6 - work may achieve or be close to publishable standard. (EF)	Excellent demonstration of skills evident in innovative and appropriate research design which is critically evaluated at an excellent level. Excellent communication and presentation with performance beyond expectation of level 6. (H/M/L)	Very good demonstration of skills evident in careful selection of appropriate research methods which are critically evaluated at a very good level. Communication is clear and structure is coherent. (M)	Good demonstration of skills evident in selection of appropriate research methods with critical evaluation of these. Communication shows clarity. (H/M/L)	Adequate demonstration of skills evident in selection of basic research methods with some critical evaluation of these. Communication is generally competent but with some weaknesses. (H/M/L)	Demonstration of skills over a reduced range. Research methods are selected but may not be entirely appropriate. Evaluation of research methods lacks criticality. Communication shows limited clarity, poor presentation, structure may not be coherent. (MF)	Demonstration of skills over a very limited range. Selection and evaluation of research methods is largely inappropriate or important research methods are ignored. Weak technical and practical competence hampers ability to demonstrate achievement of outcomes. (F/LF)

Appendix 11b: TR2 FASh with moderation of grade

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BA (Hons) Primary Education
Feedback on Assignment Sheet

<table>
<tr><td>Module Code:</td><td colspan="4">PRBA34102</td><td colspan="3">NTU Student No.:</td><td colspan="3">N0676372 TR2</td></tr>
<tr><td>Strand:</td><td colspan="4">Independent Study</td><td colspan="3">Strand Leader:</td><td colspan="3">Staff member</td></tr>
<tr><td rowspan="2">Word Count:</td><td colspan="4" rowspan="2">8,000 words</td><td colspan="3">Marker:</td><td colspan="3">Alison Murphy</td></tr>
<tr><td colspan="3">Moderator:</td><td colspan="3">Moderator 2</td></tr>
<tr><td>Date of Assessment:</td><td colspan="4">April 2020</td><td colspan="3">Overall grade:</td><td colspan="3">FIRST-LOW</td></tr>
<tr><td>Assignment title:</td><td colspan="10">'How can I …?' a critique of my developing professional practice through impact upon children's learning.</td></tr>
<tr><td>Related Teachers' Standards</td><td>TS1
✓</td><td>TS2
✓</td><td>TS3
✓</td><td>TS4
✓</td><td>TS5
✓</td><td>TS6
✓</td><td>TS7
✓</td><td>TS8
✓</td><td colspan="2">Part 2
✓</td></tr>
</table>

Areas of strength

You have identified a clear gap in research through your critical approach. You have developed the depth and breadth of your reading and defined your terms well.

You have considered OFSTED findings as well as curriculum approaches with a strong focus on curiosity and learning across the curriculum. You have included criticality and innovation within your application of reading.

You included a strong focus on child centred research and participant voice. You included implicit and explicit ethical considerations. Interpretation was focused on well and you considered methodological approaches that were complex and well thought through. This section was well reasoned and well evaluated. You really understood the challenges of the participant observation method.

You included strong interweaving of the results. You showed the action research relevance in terms of the findings. You cross-reference the cycles and methods demonstrating a complexity of analysis. Talk and questioning links with drawn in your discussion and reading was used to critique your findings well. You were aware of the limitations of participant observation within your interpretation.

This theme involves a strong comparison in perspectives and you identify where there are gaps and lack of correlation within your findings

You included a clear summary of the findings - you identified links to professional practice and the role of the researcher. You considered how the findings led to further questions to investigate in the future. You demonstrated an awareness of the appropriateness of the research methods along with the representativeness, limitations and ethical considerations of these methods

Areas for development

Areas for development related to specific assessment criteria(Please refer to the grid on next page)

Stronger links to international approaches could be highlighted demonstrating how these build upon and differ from our own context

Triangulation could have been explored further and weaved into your methods for example on page 9. Consider the ethical focus on safeguarding linked to one-to-one interviews and ethical decisions in relation to sampling methods. Consider more of the limitations and bias in relation to participant observation

Clarify your use of terms in relation to children and teachers questions. Be aware there may be more than one interpretation of the findings – this was done on page 11. Be careful not to skim over the evidence at times. Explain what the evidence was and be more specific.

Esteem was a weaker theme – it does not demonstrate a convincing argument around attitudes although attitudes are implicitly involved. Children's understanding of scientific enquiry would have been a better title for this theme. Ensure you are careful not to critique the practice of teachers and remain ethical.

Explain in more detail why you feel the need to increase the frequency of using outdoor learning. Remain tentative as you did in the discussion – include multiple possibilities in your conclusion. Include a summary statement at the end of your conclusion rather than finishing with a review of the methods

Areas for development for future assignments (Feed forward to future assignments)

Explain what the evidence was and be more specific – greater depth of analysis.

Moderation for TR1 dissertation by moderator 2 (senior lecturer primary education – internal moderation):

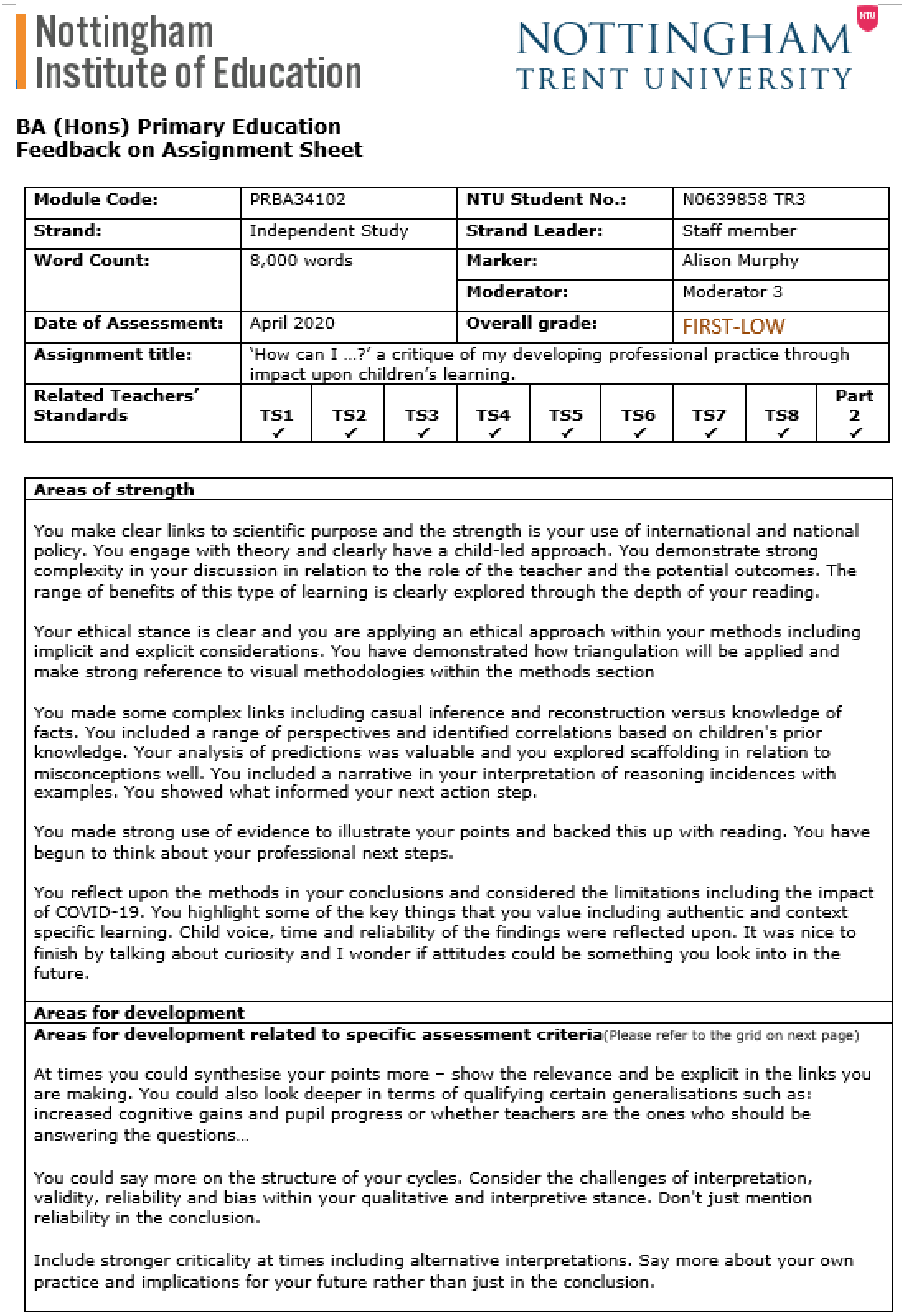
A critical analysis of findings was clearly informed by a synthesis of reading and there was a strong sense of the author's understanding of the purpose of action research and of the potential limitations it presents. There was a sense of passion and authenticity to the writing

Marking on the script was clear and explicit throughout and feedback clearly articulated strengths and specific areas for development to enable the author to move their writing forward.

Communication			Areas for development	Support links
Spelling	Pass	To improve		Improving Grammar Academic Writing Critical Thinking Preparing for assignments NTU Referencing Guide See a range of online tutorials on Lynda.Com
Grammar + syntax	Pass	To improve	tenses	
Punctuation	Pass	To improve	Capitals	
Structure	Pass	To improve		
Overall presentation	Pass	To improve	Proof read for occasional sentence clarity.	

Module learning outcomes	Assessment Criteria	Success Criteria						
		Exceptional First	First	Upper Second	Lower Second	Third	Marginal Fail	Fail
Independently judge how to use statutory and non-statutory frameworks, new initiatives, policies and reading relevant to teaching and learning and use these critically, flexibly and creatively in order to lead and innovate practice.	Demonstrates critical understanding of the research focus.	Exceptional (deep) understanding of the research focus. (EF)	Excellent (complex) understanding of the research focus. (M)	Very good (comprehensive) understanding of the research focus which is critical. (H/M/L)	Good (general) understanding of the research focus but tends towards description. (H/M/L)	Understanding of the research focus is sufficient to deal with terminology, basic facts and concepts. (H/M/L)	Insufficient knowledge and understanding of the research focus. (MF)	Highly insufficient or inaccurate knowledge or understanding of the research focus. (F/LF)
	Critical review of frameworks, policies, reading, research and theory from a range of contexts is used to inform understanding	Strong evidence of appropriate selection and critical evaluation/ synthesis/ analysis of extensive reading. Range of sources is varied, broad and deep. (EF)	Evidence of appropriate selection and critical evaluation/ synthesis/ analysis of reading. Range of sources is varied and broad. (M)	Evidence of appropriate selection and critical evaluation of reading. Range of sources is varied, but may rely on key sources to advance work. (H/M/L)	Evidence of appropriate selection and evaluation of reading. Range of sources includes some variety but is generally reliant on key sources to advance work. (H/M/L)	Some ability to select and evaluate reading, however work may be more generally descriptive. A range of sources are included but there is a general reliance on key sources. (H/M/L)	Some ability to select and evaluate reading, however work is generally descriptive. Uses a limited number of key sources to advance work. (MF)	Inappropriate or lacking in selection and evaluation of reading. Typically ignores important sources in development of work. (F/LF)
Articulate your own critical understanding of established theory, research and relevant national and international policies in relation to your practice.	Critical understanding of literature informs the interpretation of empirical material and leads to innovation within own practice.	Discussion and action arises out of informed selection, critical evaluation, interpretation and analysis of empirical material. Implications for own practice demonstrate substantial professional development. (EF)	Discussion and action arises out of selection, critical evaluation, interpretation and analysis of empirical material. Implications for own practice demonstrate clear professional development. (H/M/L)	Discussion and action arises out of selection, critical evaluation and interpretation of empirical material. Implications for own practice demonstrate insight. (H)	Discussion includes selected, evaluated and interpreted empirical material and is clearly linked to action. Implications for own practice are explored. (H/M/L)	Discussion includes some selected, evaluated and interpreted empirical material and is linked to action. Broad implications for own practice are included. (H/M/L)	Discussion includes empirical material although the selection, evaluation or interpretation could be unclear. Action may not arise out of interpretation of empirical material. Implications for own practice are poorly considered. (MF)	Empirical material is consistently underrepresented and often insufficiently selected, interpreted and evaluated. Action does not arise out of interpretation of empirical material. Implications for own practice are general and superficial. (F/LF)
Accept accountability for the informed ethical conduct of your research	Demonstrates awareness of ethical considerations pertaining to the research process, accepting accountability for own ethical conduct.	Ethical stance is conspicuously clear with ethical issues considered throughout research process. Sophisticated understanding of accountability for own research. (EF)	Ethical stance is conspicuously clear with a more complex understanding of accountability for own ethical conduct at all stages of the research. (H/M/L)	Ethical stance is clear and maintained throughout with a clear understanding of accountability for own ethical conduct at all stages of the research. (M)	Ethics protocol is clear and accountability for own ethical conduct is demonstrated. (H/M/L)	Ethics statement is included and accountability for own ethical conduct is acknowledged. (H/M/L)	Awareness of the need for ethical working is present although accountability for this is unclear or not realised through some research decisions. (MF)	Limited awareness of the need for ethical working. Accountability for own ethical conduct is not acknowledged. Research choices may not reflect ethical practices. (F/LF)
Utilise specialist research, technical, communication and professional skills critically and effectively, applying appropriately in different contexts	Research design is effective in investigating the research focus into own practice and is professionally communicated. Research methods are critically applied and evaluated.	Exceptional demonstration of skills evident in innovative research design which is critically evaluated at an exceptional level. Excellent communication and presentation with performance beyond expectation of level 6 - work may achieve or be close to publishable standard. (EF)	Excellent demonstration of skills evident in innovative and appropriate research design which is critically evaluated at an excellent level. Excellent communication and presentation with performance beyond expectation of level 6. (H/M/L)	Very good demonstration of skills evident in careful selection of appropriate research methods which are critically evaluated at a very good level. Communication is clear and structure is coherent. (H)	Good demonstration of skills evident in selection of appropriate research methods with critical evaluation of these. Communication shows clarity. (H/M/L)	Adequate demonstration of skills evident in selection of basic research methods with some critical evaluation of these. Communication is generally competent but with some weaknesses. (H/M/L)	Demonstration of skills over a reduced range. Research methods are selected but may not be entirely appropriate. Evaluation of research methods lacks criticality. Communication shows limited clarity, poor presentation, structure may not be coherent. (MF)	Demonstration of skills over a very limited range. Selection and evaluation of research methods is largely inappropriate or important research methods are ignored. Weak technical and practical competence hampers ability to demonstrate achievement of outcomes. (F/LF)

Appendix 11c: TR3 FASh with moderation of grade



Nottingham Institute of Education

NOTTINGHAM TRENT UNIVERSITY

BA (Hons) Primary Education
Feedback on Assignment Sheet

Module Code:	PRBA34102			**NTU Student No.:**	N0639858 TR3				
Strand:	Independent Study			**Strand Leader:**	Staff member				
Word Count:	8,000 words			**Marker:**	Alison Murphy				
				Moderator:	Moderator 3				
Date of Assessment:	April 2020			**Overall grade:**	FIRST-LOW				
Assignment title:	'How can I ...?' a critique of my developing professional practice through impact upon children's learning.								
Related Teachers' Standards	**TS1** ✓	**TS2** ✓	**TS3** ✓	**TS4** ✓	**TS5** ✓	**TS6** ✓	**TS7** ✓	**TS8** ✓	**Part 2** ✓

Areas of strength

You make clear links to scientific purpose and the strength is your use of international and national policy. You engage with theory and clearly have a child-led approach. You demonstrate strong complexity in your discussion in relation to the role of the teacher and the potential outcomes. The range of benefits of this type of learning is clearly explored through the depth of your reading.

Your ethical stance is clear and you are applying an ethical approach within your methods including implicit and explicit considerations. You have demonstrated how triangulation will be applied and make strong reference to visual methodologies within the methods section

You made some complex links including casual inference and reconstruction versus knowledge of facts. You included a range of perspectives and identified correlations based on children's prior knowledge. Your analysis of predictions was valuable and you explored scaffolding in relation to misconceptions well. You included a narrative in your interpretation of reasoning incidences with examples. You showed what informed your next action step.

You made strong use of evidence to illustrate your points and backed this up with reading. You have begun to think about your professional next steps.

You reflect upon the methods in your conclusions and considered the limitations including the impact of COVID-19. You highlight some of the key things that you value including authentic and context specific learning. Child voice, time and reliability of the findings were reflected upon. It was nice to finish by talking about curiosity and I wonder if attitudes could be something you look into in the future.

Areas for development

Areas for development related to specific assessment criteria(Please refer to the grid on next page)

At times you could synthesise your points more – show the relevance and be explicit in the links you are making. You could also look deeper in terms of qualifying certain generalisations such as: increased cognitive gains and pupil progress or whether teachers are the ones who should be answering the questions…

You could say more on the structure of your cycles. Consider the challenges of interpretation, validity, reliability and bias within your qualitative and interpretive stance. Don't just mention reliability in the conclusion.

Include stronger criticality at times including alternative interpretations. Say more about your own practice and implications for your future rather than just in the conclusion.

At times you rely on just one example for instance 'an unexpected result'. Can you go deeper with this analysis?

Ensure your ethical stance is articulated through your choices. You have thought about the appropriateness of your methods but you need to explain more about the two groups. Are there any challenges that you have encountered?

Consider your future questions and the things you still want to find out - what do you not know? This may include attitudes to go alongside children's perceptions that you were discussing in relation to semi-structured interviews.

Areas for development for future assignments (Feed forward to future assignments)

You include your professional next steps but it would be nice to see these within the first theme in your discussion - not just in your conclusion.

Moderation for TR3 dissertation by moderator 3 (principle lecturer for initial teacher training – cross course moderation):

I was impressed by this student's work, particularly the extensive reading they have undertaken and that they use to support their discussion. Reading it before I had looked at the FASh, it definitely felt like a first. I completely agree with your development points about synthesis and criticality. It did, at times, feel that they were trying to cram so much in that they didn't leave the space to 'dig deeper'.

Communication			**Areas for development**	**Support links**
Spelling	Pass	To improve		Improving Grammar Academic Writing Critical Thinking Preparing for assignments NTU Referencing Guide See a range of online tutorials on Lynda.Com
Grammar + syntax	Pass	To improve	See notes on grammar, repetition	
Punctuation	Pass	To improve	Reference punctuation needs to be consistent	
Structure	Pass	To improve	Ensure you have a balance – long literature review	
Overall presentation	Pass	To improve	Figures should appear in order.	

Module learning outcomes	**Assessment Criteria**	**Success Criteria**						
		Exceptional First	**First**	**Upper Second**	**Lower Second**	**Third**	**Marginal Fail**	**Fail**
Independently judge how to use statutory and non-statutory frameworks, new initiatives, policies and reading relevant to teaching and learning and use these critically, flexibly and creatively in order to lead and innovate practice.	Demonstrates critical understanding of the research focus.	Exceptional (deep) understanding of the research focus. (EF)	Excellent (complex) understanding of the research focus. (L)	Very good (comprehensive) understanding of the research focus which is critical. (H/M/L)	Good (general) understanding of the research focus but tends towards description. (H/M/L)	Understanding of the research focus is sufficient to deal with terminology, basic facts and concepts. (H/M/L)	Insufficient knowledge and understanding of the research focus. (MF)	Highly insufficient or inaccurate knowledge or understanding of the research focus. (F/LF)
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Accept accountability for the informed ethical conduct of your research	Demonstrates awareness of ethical considerations pertaining to the research process, accepting accountability for own ethical conduct.	Ethical stance is conspicuously clear with ethical issues considered throughout research process. Sophisticated understanding of accountability for own research. (EF)	Ethical stance is conspicuously clear with a more complex understanding of accountability for own ethical conduct at all stages of the research. (H/M/L)	Ethical stance is clear and maintained throughout with a clear understanding of accountability for own ethical conduct at all stages of the research. (H)	Ethics protocol is clear and accountability for own ethical conduct is demonstrated. (H/M/L)	Ethics statement is included and accountability for own ethical conduct is acknowledged. (H/M/L)	Awareness of the need for ethical working is present although accountability for this is unclear or not realised through some research decisions. (MF)	Limited awareness of the need for ethical working. Accountability for own ethical conduct is not acknowledged. Research choices may not reflect ethical practices. (F/LF)
Utilise specialist research, technical, communication and professional skills critically and effectively, applying appropriately in different contexts	Research design is effective in investigating the research focus into own practice and is professionally communicated. Research methods are critically applied and evaluated.	Exceptional demonstration of skills evident in innovative research design which is critically evaluated at an exceptional level. Excellent communication and presentation with performance beyond expectation of level 6 - work may achieve or be close to publishable standard. (EF)	Excellent demonstration of skills evident in innovative and appropriate research design which is critically evaluated at an excellent level. Excellent communication and presentation with performance beyond expectation of level 6. (H/M/L)	Very good demonstration of skills evident in careful selection of appropriate research methods which are critically evaluated at a very good level. Communication is clear and structure is coherent. (H)	Good demonstration of skills evident in selection of appropriate research methods with critical evaluation of these. Communication shows clarity. (H/M/L)	Adequate demonstration of skills evident in selection of basic research methods with some critical evaluation of these. Communication is generally competent but with some weaknesses. (H/M/L)	Demonstration of skills over a reduced range. Research methods are selected but may not be entirely appropriate. Evaluation of research methods lacks criticality. Communication shows limited clarity, poor presentation, structure may not be coherent. (MF)	Demonstration of skills over a very limited range. Selection and evaluation of research methods is largely inappropriate or important research methods are ignored. Weak technical and practical competence hampers ability to demonstrate achievement of outcomes. (F/LF)

Appendix 12a: TR1 initial notes

Contextual information:

XXX Primary School is a larger than average-sized primary school. There are two classes in each age group, and separate provision in the Nursery and reception. The large majority of pupils are White British, with a proportion of pupils from a range of ethnic backgrounds. The proportion of pupils from whom the school receives pupil premium is above average.

Placement comment:

TR1 has shown a real enthusiasm to teaching. She has planned and delivered a range of engaging and creative lessons across the curriculum which shows in the progress the children have made, especially in science. TR1 ran an after-school science club for the year 2 children (which developed children's curiosity with science and the links to the outdoors) where they focused on questioning and predicting. She extended children's vocabulary in science. She planned creative sessions that developed children's curiosity and their confidence in discussion-based activities. She gave science a purpose by introducing the topic with an interesting hook.

Placement interview:

1. I ran a science club with year 2
2. I did some outdoor learning with my Y1 class.
3. The children went wild and struggled with transitions.
4. We looked at birds and nests
5. Question hands were collected in, one before and one after.
6. The second one was more child led.
7. Inside they couldn't come up with questions but outside they could.
8. There was more trust outside.
9. There was less structure.
10. The children were more enquiring.
11. Got more out of the children.
12. More talk involved.
13. I made learning journeys.
14. Contextual learning was not just outdoors.

Appendix 12b: TR2 initial notes

Contextual information:

The school is an average-sized primary school. There are some classes which contain mixed-year groups of pupils. The proportion of disadvantaged pupils is similar to the national average. The proportion of pupils with SEND is close to the national average. Most pupils are from White British backgrounds.

Placement comment:

TR2 has successfully planned and taught sequences of lessons that impart knowledge and understanding and has shown a progression in learning over time. These lessons have been engaging and children have enjoyed them, in particular science and PE lessons. Children's curiosity has been developed through outdoor learning and the use of KWL grids has allowed children to share their questions. Lessons are well structured; for example, starters, objectives and aims shared, activities, mini plenaries and plenary and many have had interesting starts to hook the children's interest. Lessons consistently recap the previous lesson and often lead on to the next session. TR2 has reflected and adapted lessons in light of evaluations and feedback from other professionals. TR2 has used targeted questioning based on ability. TR2 has considered challenges in planning and during lessons to progress learning. She maintained high standards during lessons showing high enthusiasm such as in Outdoor Learning. TR2 has demonstrated strong pupil teacher relationships rooted in mutual respect, exercising authority and acting decisively where necessary.

Placement interview:

1. When teaching plants I used prior assessment to find out what they noticed.
2. What do they know already
3. Their questions were collected.
4. Why are leaves falling off trees and their life cycle.
5. Mushrooms were found in the forest and lessons were designed on fungi.
6. There was outdoor space at school but it was so big it was hard to capture what they were doing.
7. Could get answers when asked questions.
8. Didn’t have their own cameras – would have worked well to capture the info.
9. Can narrate findings in the next meeting.
10. Signposts of progress to know and answer questions – fed off each other to make links.
11. Made connections between different things.
12. Enjoyed contextual learning.
13. Behavioural problems hard when outdoors.
14. Taught others not to walk through mud.
15. The more they went out, the more the wanted to go out.
16. Children enjoyed the freedom.
17. Child led.
18. Children enjoyed it.
19. Collaborative learning.
20. Proud if they found something.
21. Paired work.
22. Progress in reasoning and scientific thinking.
23. Being outside helped to link to different contexts.
24. Sorting and classifying was more effective outside.
25. Increased engagement and increased sense of achievement.

26. Doing plants, they can see changes - if this was repeated in spring they would get a lot from them.
27. Outside could answer each other's questions.
28. Would like to do it when not on placement.
29. Made a display.

Appendix 12c: TR3 initial notes

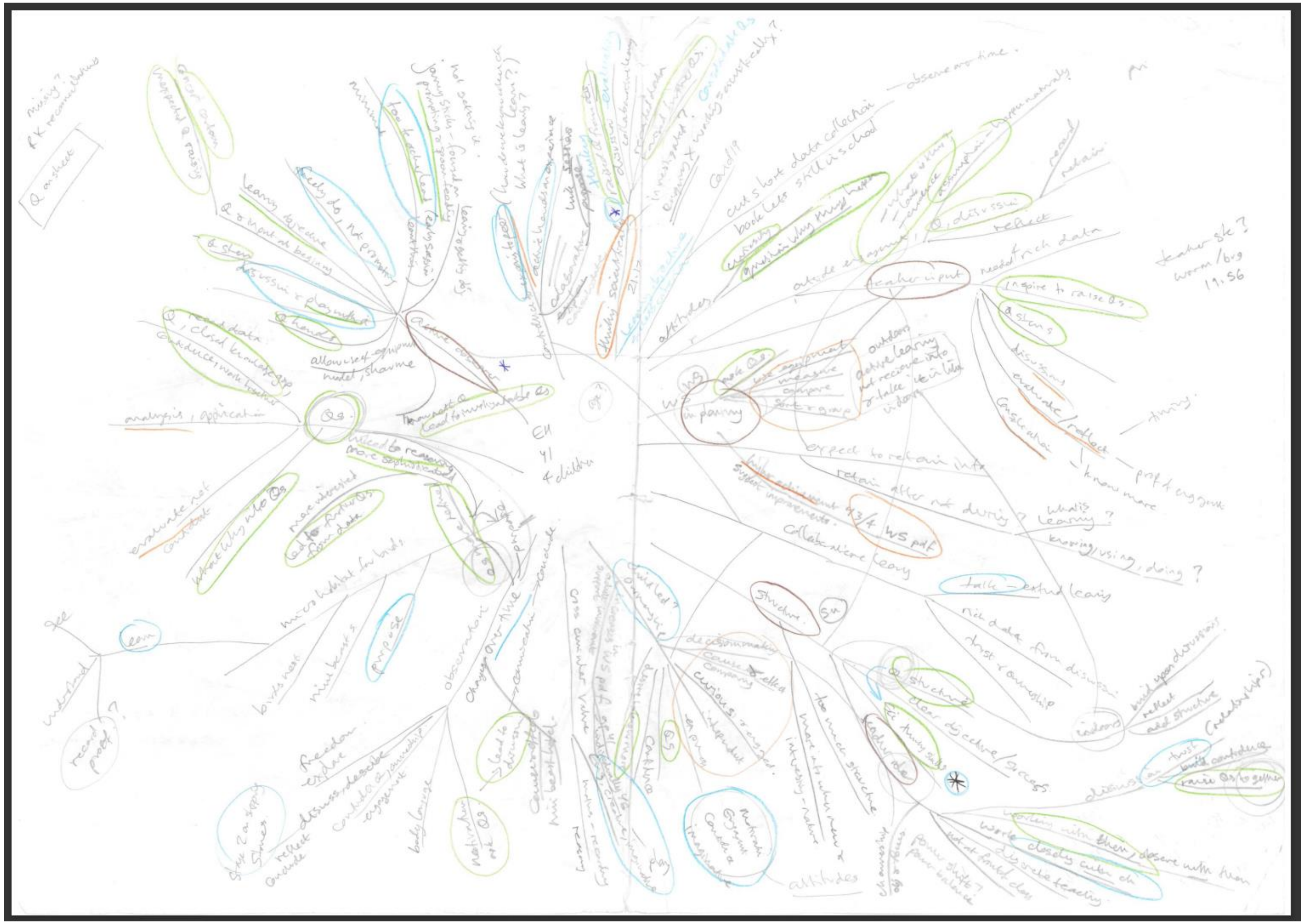
Contextual information:

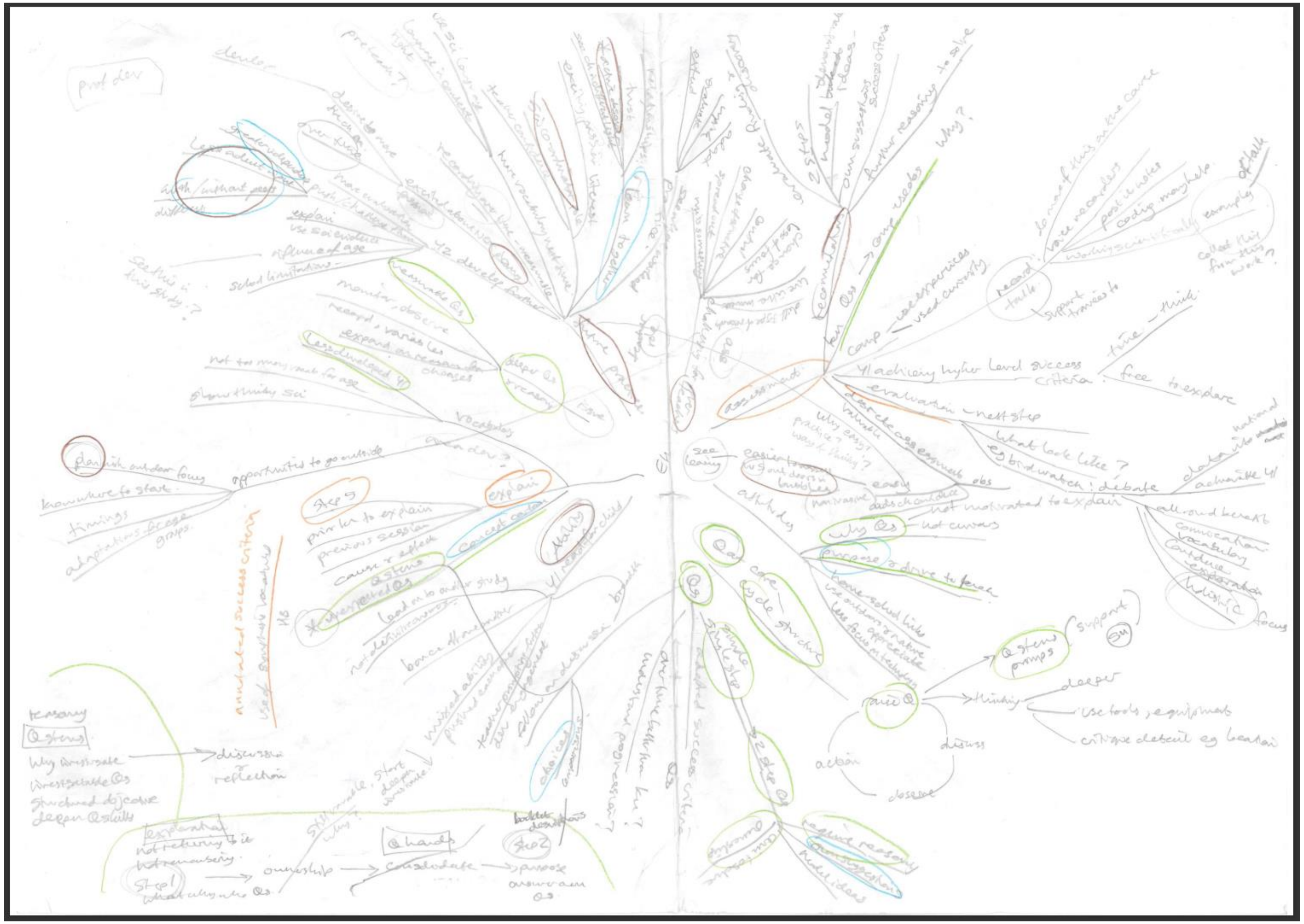
XXX is a medium to large village in the heart of Nottinghamshire. It has a predominantly White British intake with a small percentage of ethnic groups. XXX's last Ofsted was in January 2018 and was graded as a good. Feedback brought about by the inspection was to tighten up and expand on how data is collected and used within school. Learners generally come in with good understanding in reading and maths. Our percentage of SEN is 9% and Pupil Premium is 10 %. XXX has a bronze mark in PE for School Games, a Bronze Award for Eco-Schools and is also a beacon school for Third Space Maths. XXX a very low percentage of behaviour difficulties and accesses the local SBAP for only a few child presently. Reading and writing are currently high priority on the School Improvement Plan to develop greater depth across the Key Stage 1 and 2. a reasonably high percentage of children come from outside the XXX catchment to attend XXX. Children from 4 local towns and villages attend our school. The percentage of EAL is less than 2% and all children are proficient English Speakers.

Placement comment:

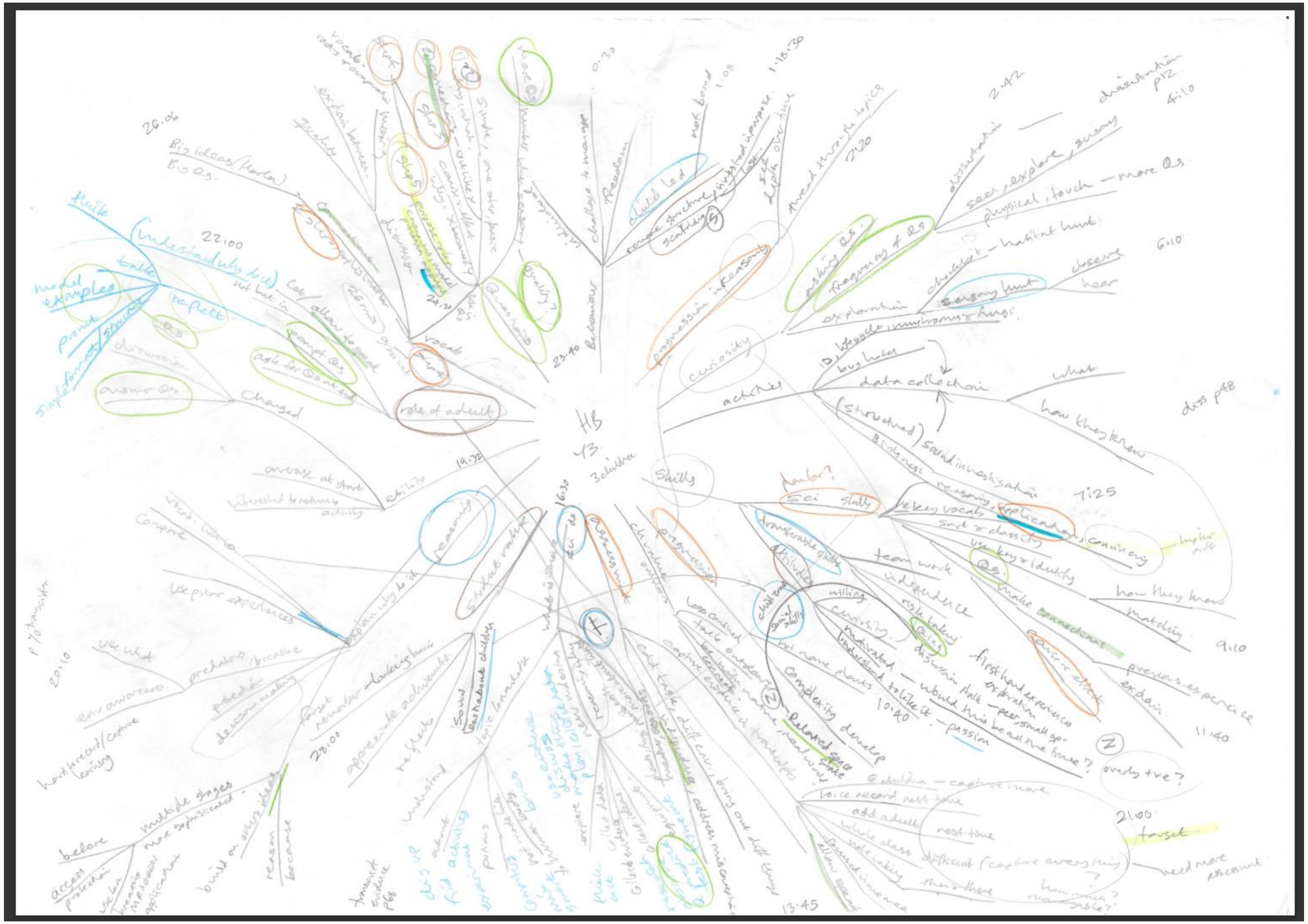
TR3 has successfully carried out her placement at XXX and has shown superb organisation and a drive to teach to the highest of standards. She has set high expectations of all learners and has begun to tailor her teaching to meet the needs of specific groups such as SEN and GDS. TR3 has used lesson observation feedback appropriately to adapt following lessons to include techniques to further enhance effective learning. Teaching techniques and subject knowledge discussed in Staff Professional Development meetings have been effectively applied in the next appropriate lesson. TR3 is extremely intuitive and responds very well to professional feedback. She has taken lessons outside of the classroom and used the school environment to enhance learning.

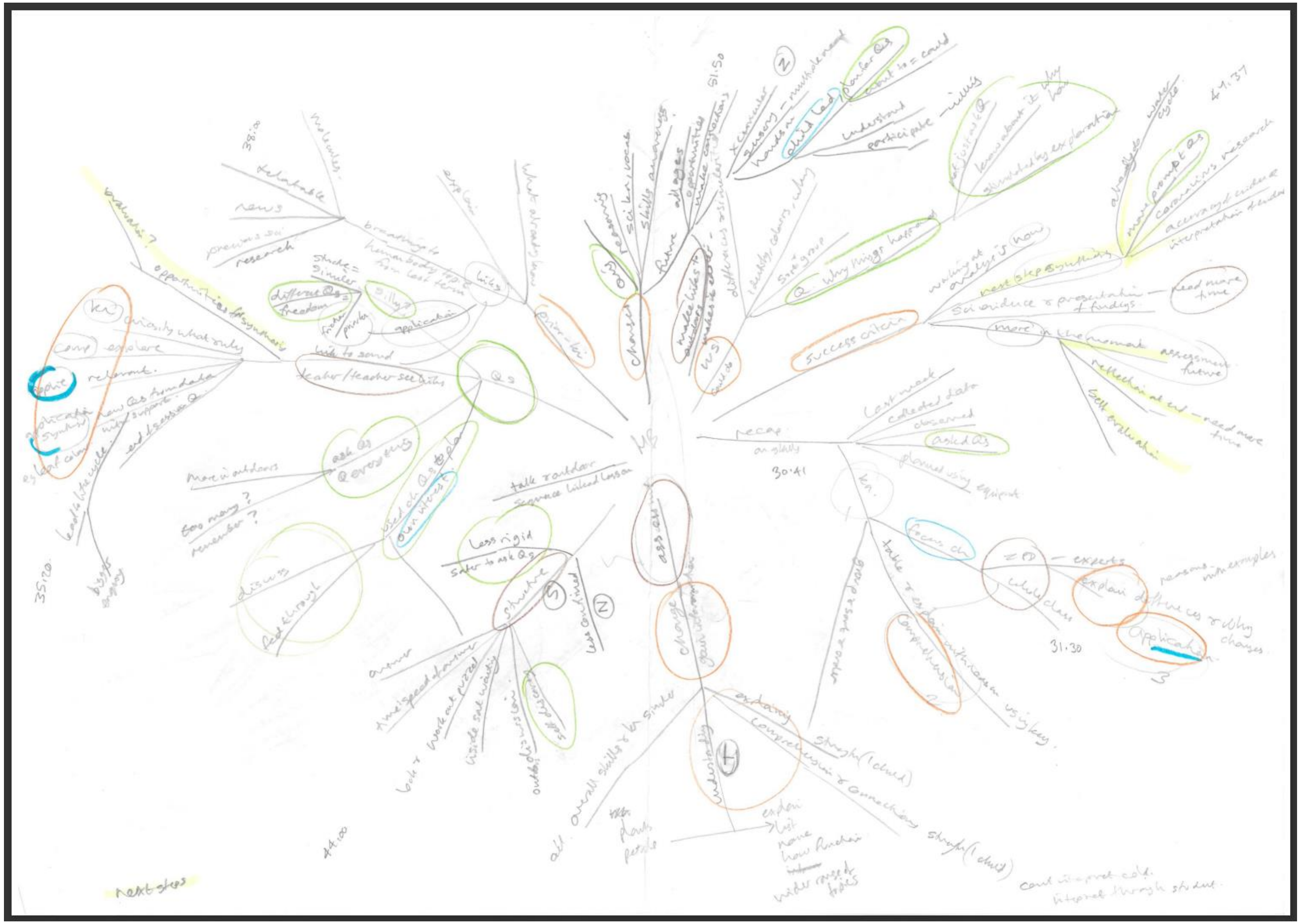
Appendix 13a: TR1 mind maps



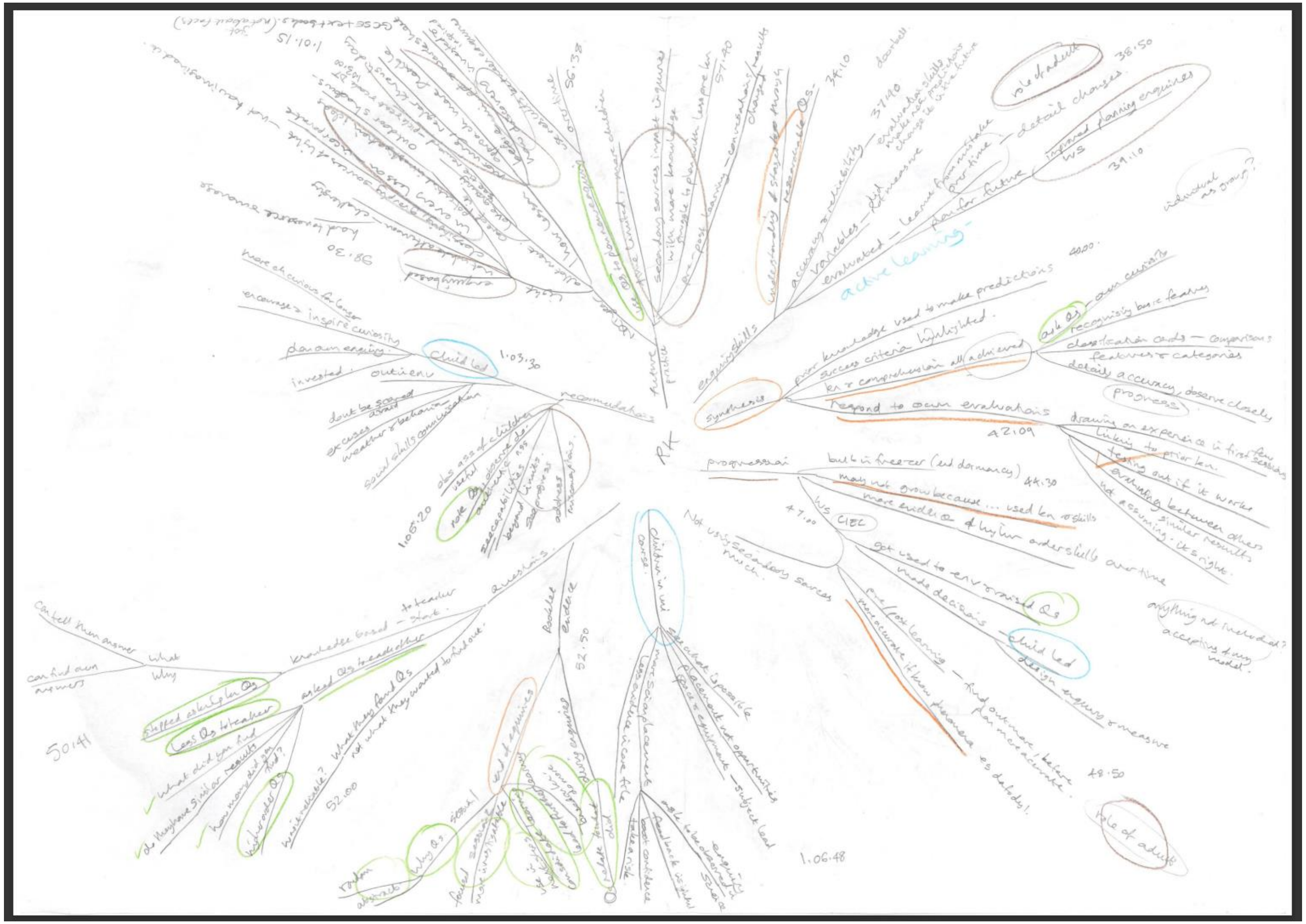
prof dev
Y2 develop further
Y1 achieving higher level success criteria
time – think
free to explore
assessment
evaluation – next step
what look like?
eg birdwatch : debate
achievable Y1
all-round benefit
communication
vocabulary
confidence
explain
step 3
prior kn to explain
previous session
cause + effect
concept cartoon
Q stems
deeper Qs
reasoning
vocabulary
opportunities to go outside
know where to start
timings
adaptations – groups
cycle structure
2 step Q
Q stems prompts
support
deeper
use tools, equipment
critique detail eg beaches
action
discuss
observe
reasoning
Q stems
why investigate
investigable Qs
structured to cover deeper Q skills
discussion
reflection
explanation
Step 1
ownership
consolidate
purpose
Q hands
Step 2
booklets
see learning
easier to assess
attitude
why Qs
not curious
purpose to drive to focus
not motivated to explain
annotated success criteria
used booklets

Appendix 13b: TR2 mind maps




MB
38:00
molecules
relatable
news
previous sci
research
breathing to
human body topic from last term
links
explain
what already know
Struct = Similar
different Qs
freedom
Billy?
finish
priorities
application
link to sound
teacher / teacher see links
Qs
evaluation?
opportunities for synthesis
kn
curiosity what only
comp
explore
applic
relevant.
application
synthesis
how Qs from data
with support
end of session Q
eg leaf colour
leads to life cycle
35:20
bigger enquiry
More in outdoors
ask Qs
Q everything
too many ?
remember ?
used ch Qs to plan
own interest
discuss
fed through
talk & outdoor
Sequence linked lesson
Less rigid
Safer to ask Qs
structure
S
N
Less confined
answer
time/speed of answer
look & work out puzzle
inside sat waiting
outdoors discussion
self discovery
44:00
all overall skills & ... similar
plants
petals
next steps
own
reasoning
sci knowledge
skills answering
future
all ages
opportunities
make connections
choose
make links to outdoors
makes sense
WS
could do
differences & similarities
x curricular
sensory
hands on
multiple meaning
child led
similar Qs
about to = could
Z
51:50
understand
participate
identify, colours, why
sort group
Q why things happen
not just ask Q
know about it
why how
stimulated by exploration
success criteria
looking at analysis how
next step synthesis
already
water cycle
more prompt Qs
carry out research
accuracy & evidence
interpretation & evidence
41:37
Sci evidence & presentation of findings
need more time
more in the moment
assessment future
reflection at end – need more time
Self evaluation
recap
on skills
30:41
Last week
collected data
observed
asked Qs
planned using equipment
kn.
focus ch
ZPD
experts
whole class
explain differences & why changes
reasons with examples
Application
31.30
table & explain
comprehension
using key
ass
change
explaining
strength (1 child)
comprehension & connections
understanding
explain
list
name
how function
wider range of topics
strength (1 child)
could interpret colour
interpret through student

Appendix 13c: TR3 mind maps


RK
future
practice
enquiry skills
synthesis
prior knowledge used to make predictions
40.00
success criteria highlighted
kn + comprehension all achieved
respond to own evaluations
42.09
ask Qs – own curiosity
recognising basic features
classification cards – comparisons
features + categories
details accuracy, observe closely
progress
drawing on experience in first few sessions
linking to prior kn.
testing out if it works
evaluating between others
not assuming similar results
assuming – its right.
active learning
accuracy + reliability
variables – did not measure
evaluated – learn from mistake over time – detail changes
plan for future
improved planning enquiries
WS
39.10
38.50
role of adult
37.40
doorbell.
34.10
individual as group?
understanding of stages of process
responsible Qs.
secondary sources impact inquiries
with more knowledge
struggle to plan when less pre kn
pre-post learning – conversations/results changes
57.40
use Qs to plan own enquiry
56.38
over time
progression
built in freezer (end dormancy)
44.30
may not grow because ... used kn + skills
more evidence of higher order skills over time
47.00
WS
CIEC
Not using secondary sources much.
got used to environment Qs
made decisions – child led
design enquiry + measure
pre/post learning – find out more / before plan more accurate.
more accurate if know phenomena es dafodys!
48.50
anything not included?
accepting of any model.
role of adult
1.06.48
children in uni course.
see what is possible
placement not opportunities
focus + equipment – subject lead
more Sci placement
less evidence in one file
able to be observed in science
enquiry
feedback is helpful
boost confidence
take a risk
Booklet
evidence
52.50
questions.
knowledge based – to teacher – start.
asked Qs to each other
What they found Qs not what they wanted to find out.
was it reliable?
52.00
stopped asking teacher Qs
Less Qs to teacher
What did you find
do they have similar results
how many did you find?
higher order Qs
What
Why
Can tell them answer
can find own answers
50.41
random
abstract
Why Qs.
focused
seasonal
more investigable
kind of enquiries
relate to what did
O Qs
recommendations
child led
1.03.30
encourage + inspire curiosity
more ch curious for longer
plan own enquiry
invested.
outdoor env
don't be scared afraid
excuses
weather + behaviour
social skills communication
obs ass of children
useful
role Qs
observe do
evidence
see capabilities
beyond limits
see progress
address misconceptions
1.05.20
58.30
1.01.15
GCSE text books (not about facts)

Appendix 14: Combined evidence for themes and sub themes

Themes:

Theme: thinking scientifically (orange on mind maps)

- TS1 green
- TR2 purple
- TR3 black
- Red is for my questions/comments

Sub topic	Evidence / Interpretation	Associated reading
Knowledge	Curiosity including what and why questions.	
Comprehension	Have the confidence to explain active hands-on experience to a peer. Exploration. Comprehension and connection became a strength for one child. They were able to list and name the function of plant parts e.g., petals.	
Application	Measurable questions – what change, measure, keep the same. Saw the relevance of the exploration. Drawing links to learning from last term e.g., breathing from the human body topic. Able to explain that they already knew using prior learning. Birds nest example – included reasoning and convincing argument – higher order thinking.	
Analysis	TR1 interview 13:54. Analysis and application were demonstrated through their use of questioning. Was aware of planning for opportunities for synthesis. New questions from the data with support Y3 e.g., leaf colour led to the life cycle and a bigger enquiry. (Difficult to separate analysis and synthesis)	P28 Loxley Three stage framework
Synthesis	Prior knowledge used to make predictions. 40:00 Success criteria highlighted (some points are individual examples but a lot are talking about the children as a group). Responding to own evaluations - Drawing on experience in first few sessions. Linking to prior knowledge. Testing out if it works. Evaluating between others and similar results. Not assuming its right 43:41 (detailed examples of what the children could do). Annotated success criteria. Use of synthesis terms in teaching approach.	
Evaluation	TR1 interview 30:50, 53:47. The next steps for the children would be to debate. Lacked confidence in evaluation. Less opportunity for evaluation. Reflection at the end – need more time for this. Self-evaluation e.g., booklet work. Explaining became a strength for one child.	

Thinking changed	Authentic process, naturally occurring, time, child led. Noticing different things. AfL - Understanding the stages to go through (self-efficacy?) and the value of researchable questions. Learnt from mistakes and improved planning over time (not considered enquiry skills here – why?). Awareness of accuracy and reliability. Knowledge and comprehension all achieved. Higher order less consistent attainment e.g., ask Qs, recognise basic features, compare features and categories using classification cards. Made progress with detail, accuracy, observe closely. Taken on board. Evidence in booklets: random abstract responses, focused and more investigation led, consolidate learning and considered next steps, led to further learning (overlap with questioning?) Thinking was developed through discussion. Timing of evaluation and reflection demonstrated engagement and consolidation of their learning. Gain information and a better understanding. Questioning, reasoning. Scientific knowledge and understanding. Vocabulary and skills awareness. They questioned why things changed, they didn't just ask questions. Stimulated by exploration but wanted to know why and how with a purpose. They could sort and group, identify colours and reasons. Notice similarities and differences. Progression in reasoning – see depth over time. Has been a thread through the topics covered.	CASE Blooms
Scientific skills	The children in Y1 were achieving expectations for Y3&4 (Working Scientifically pdf CIEC). They were able to suggest improvements to their work. (The issues they have are related to vocabulary 31:00). Using equipment, measuring, comparing and sorting, and grouping were observed in the outdoor learning. Using key vocabulary, sort and classify, use a key and identify – awareness of how they know. Matching. Cause and effect, making connections between previous experiences and being able to explain this.	
Child related expectations	English and Maths were clearly understood and meeting age related expectations. Didn't have the same knowledge about science. Prior experience and science motivated (allotment) resulted in the child exceeding expectations. Could make sci predictions as a result. 'Use what I already know to help me explain new things' bulb root example (understand). High expectations were set and enabled for decision making, comparing, cause and effect. Attitudes and ways of working included: curious and engaged, independent, expression, imagination, motivation, confidence.	146 Serret and Earle Thinking and big questions

	Questioning and success criteria utilised to enable the children to understand the next steps e.g., synthesis (e.g., water cycle, coronavirus research and accuracy and interpretation of evidence). Attitudes: keen to return to the activity.	
(step 1)	Simple, one step, basic. Why and what questions.	
Understanding (step 2)	Descriptions and simple explanations. Described what saw and did. Sorting and grouping. Outdoor resources enabled this. Opinions shared. encouraging problem solving. Repetition and agreement. Naturally independent and share. Make connections – is it like X?	
Cause and effect (step 3)	Seeing relationships. Using their knowledge and linking this to their findings. Ch had an awareness that if competed at a different time, there may have been different results e.g., an awareness that the occurrence (popularity) of mini beasts changed linked to seasons and weather 23.14 Linked to experiences. Cause and effect – why? Is X because of Y?	P92 Serret and Earle Progression
Sci vocab (step 4)	Classify and group mini beasts. Repeat and apply vocabulary with a different focus (not simply recall) 19:57. Use knowledge in the future. Realise the benefits of learning over time. Results led to new predictions, raised new questions e.g., bulb in freezer (end dormancy) and mini beast season. Used knowledge to suggest why it may not grow. 47:00. Is this the 4th step – where does it fit in? suggested steps? Pre and post learning helped with these examples – find out more before so plan is more accurate. Knowing the lifecycle of the daffodil meant the activity was more accurate. Vocabulary e.g., roots and evaporation. 2 steps and sophistication – vocabulary associated with wet grass 26:00. Developing Harlen's big ideas (focus in Y2 of BA course).	Compare my findings of learning outcomes to p205-207 Serret and Earle
Prediction skills and reasoning (step 5)	Use pre-existing knowledge e.g., banana peel and mouldy bread. What they have already seen. Misconceptions self-addressed leading to reasoning. Compared drawings and lifecycle of a daffodil. Used this to design a new enquiry. Evaluate and made new predictions 27:00 Evaluation – debate linked to the birdwatch national data (achievable for Y1). Being able to explain. Using prior knowledge, linking to the previous session. Giving reasons for cause and effect. Purpose and knowledge. Coronavirus, model process. Applying their knowledge.	Zimmerman 2018 Scientific thinking
Assessment	Age – how does this influence findings?	Exploratory and dialogic talk p49

	Capture evidence of thinking scientifically in transcripts, in the booklets, note taking there and then. Allowing them to speak. Focus in one area or on one group of children. Acknowledging what is manageable/purposeful. Target for practice.	Loxley. Mercer 2000

TR3 spoke more about the steps whereas TR1 spoke more about the success criteria, what caused the difference and was one more insightful than the other in terms of progression?

2 approaches used success criteria and steppingstones. What do each tell us and what are the commonalties/differences?

Theme: questioning (green highlighting on mind maps).

Sub topic	Evidence and interpretation	Associated reading
Curiosity generated questions	Attitudes, interests, discovery, stimulus to explore and observe, time on task and engagement in learning. X3 (TR3 time). Authentic real-life context stimulated further questions 8:50 Question why things happen – curiosity. Engagement and observation, identification, evidence. Motivation related to them asking questions which led to discussion. Would this be all of the time or a novelty? Overly positive interpretation? Raised questions from observations. Raised further questions. Curiosity led to asking questions. Frequency of questions through exploration. Physical, touch, sensory resulted in more questions being asked. More questions outdoors than indoors. There were too many for them to remember. They questioned everything. Using the outdoors makes questioning easier through hands-on chid led. Children didn't just ask questions. They were stimulated by exploration – desire to know about it. More questions when sensory but what was the quality and did it develop skills to apply in later lessons. Did they see a purpose for their Qs – did they intend to find an answer? Are some questions silly?	Jirout & Klahr 2012 Harlen 1985 taking the plunge Roden 2007 sage – eBook Jelly – productive and unproductive questions. Watson & Goldsworthy AKSIS Sharp 2004 Harlen 2012 p66 Johnson 2005 - chapter 4 attitudes.
Questions underpinned child led approach	Assumption it would naturally happen. Rising questions together within discussion, built trust, relationships and confidence. Have ownership of their questions with a desire to know and find out more. Too teacher led, too much prompting and spoon feeding at the start limited their questions. Children in a relaxed space. Allowed to have a voice/able to speak. Demonstrate independence. Questioning is part of collecting children's ideas and predicting. Build on others' ideas and questions.	Johnson 2005 Plowden, DES 1967 child centred approach. McEwan 2016 the role of the practitioner involvement.

	Used the children's questions to plan based on their own interests – discuss and fed through. Began to look for answers in their questions. Less rigid structure resulted in the children feeling safer to ask questions –less confined focus on self-discovery. How does this relate to the child led section?	
Role of the adult	Enabled the teacher to address misconceptions Teacher planned for children's questioning in order to develop their Working Scientifically skills. Timing of questioning not explored. Techers need to inspire children to raise questions. Questions stems and question hands can support this (play with it). Working WITH and alongside the children – different approach. Use scientific thinking skills to structure the questioning objectives. Unexpected question raising can be challenging, including q raised as a result of concept cartoons. Questioning was a learning objective. Prompt questions and allow children to ask Qs. Model thinking, talking, question examples, reflection, observing in the moment and ask for questions at the end (expectation from the children that they will be given the chance to ask questions). Hard for teachers to plan for children's questions. Was important to value questions, remember them and revisit them. How does this relate to the role of the adult section?	125 Serret and Earle teacher questions Harlen 2012 p65 anxiety p22 Cross & Bowden Harlen 2012 p69 handling children's questions Keogh & Naylor 1999 an evaluation.
Challenge/depth	Use prior experiences and prior knowledge when developing higher order questions. Questioning feeds into discussion (retention and reflection) engagement, desire to know more, consolidation. Difficult to separate Questioning from discussion. Deeper questioning and reasoning including questions with responses that are measurable. Y1 less developed vocabulary which can limit expectations for questions. Knowledge questions develop to include greater comprehension and use observations.	P40 Serret and Gripton 154 Harlen and Qualter Driver, Newton & Osborne. Establishing norms of sci augmentation.
Progression in children's questions	What, why, knowledge-based questions become higher level of thinking, different time, measure x lead to y. 10:40 Results led to new questions. Questions became more refined over time with a purpose. Led to further questions from the data. More interested. What, why, who questions (at the start). Questioning became linked to reasoning and was more sophisticated.	P43 Serret and Gripton P148 Harlen and Qualter Goldsworthy, Feasey and Ball p20

	Questioning closed the knowledge gap, related to the data and lead to increased confidence and group working. Lead to investigable questions (with dependent and independent variables). Simple single step questions led to 2 step questions which require reasoning, involve own suggestions, have an intention to solve them, have ownership. Explore student model – how does this relate to theoretical models and other student views? Moved from asking questions to answering own questions. 1) Simple one step basic – why, what Questions. 2) Connections – is it like x? 3) Cause and effect. Is x this because of y? 4) Vocabulary 5) Purpose and knowledge of question through application. How does this relate to the thinking scientifically section?	
Choices and decision making	The teachers thinking has changed and now plans to promote choices and decision making. Questions are at the core – cycle structure: raise questions, discuss, observe, action, raise questions. Explore student model Scientific skills - Asking questions allowed them to make connections with previous experience and explain. Also seen as a transferable skill. Questioning is part of talk.	Alexander 2000 Mercer – dialogic discourse
Q during post-learning reflection	Booklet: session 1: Qs seem more random and abstract – why questions. Later sessions – More focused and more investigable. Can use them in next steps Consolidate learning. Lead to further learning. Based on prior-knowledge. Used questions to plan future enquiry over time using results between enquiries.	
Q in the moment,	At the start they asked questions to the teacher. Over time, they asked questions to each other and less to the teacher. Higher order questions e.g. comparing results/findings. Asked less knowledge questions (with greater independence) and related to what they did 52:50. Why questions – they were not curious and not motivated to explain. Needed a purpose and drive to know.	
Assessment	Teacher needs to get better at noting questions and observing as they learn – more authentic.	

Theme: child led learning (blue on mind-maps)

Sub topic	Evidence /Interpretation	Associated reading
Planning	Teaching has changed to discovery learning and decision making 01:00. Can't plan for child led. Involves the children noticing different things. Planning from their own interests and leaving space for choices e.g., choice of equipment. (Student spoke about evaluation – it seemed to be an assumption that the children were active learners in the approach). See role of adult: prompting and spoon feeding, focused on learning and getting objective). Became freer and not prompting. Enabled them to question and discuss and 'play with it'. Allowed use of equipment, modelled, 'show me' sharing examples. Value creative and imaginative play Focus on the children – include ZPD with more knowledgeable other – use to support differentiation and challenge. Used children's questions to plan – based on the children's interests	
Talk	Real-life contexts provide stronger starting points for children's discussion Giving children the ownership of discussions involves trust (relationships with the children – specific part of outdoor learning?) build confidence and raise questions together. Collaborative learning where the children's talk extends learning (intertwined). Link sessions and purpose. Confidence to explain to a peer (how you know when children learn? Understanding of theory?). Active hands-on experience. Choices, use of concept cartoons and question stems are child led. Reasoning – ownership for explaining why they did it.	P175 Dunn and Peacock 2015
Purpose	Children understand the purpose. See and understand and record the learning for themselves. The purpose and attitudes give the children the drive to know more. Exploration, focus on the senses - sensory hunt – what observe and hear. Transferable skills were listed and they all involved child led approach e.g. team work, independence, risk taking, first-hand exploration, questioning and discussion. Practical science had an active learning approach e.g., find, dig up, mix, experiment, use evidence, discuss, make, collect evidence, collect data, think, act, explore,	p84, p85 Dunn and Peacock

	research, collect ideas, observe, predict, test, figure out (not explicitly child led comment). Children's views were sought.	
Training	Focus on exploration approach in Y1 and Y3 – were able to see what was possible in a safe environment, placement not had the opportunities, less evidence in core file, have looked for opportunities to teach science on placements e.g., asked to be observed when teaching enquiry, feedback was insightful, boos confidence, need to take a risk. Plans for more child led in NQT year.	
Attitudes	More children were curious for longer, encourage and inspire curiosity. Ownership in terms of decision-making, comparing, cause and effect, curios and engaged, independent and expressive. Saw attitudes such as: motivation, engagement, confidence and imagination.	Context – curiosity Ofsted 2013 and p120 Serret and Earle shared ownership
Ownership	Plan own enquiry, invested on the work, focus on social skills and communication. More decisions became child led e.g., designing enquiry and deciding what to measure. Demonstrating progression in Working Scientifically. See the reward (NQT/ECT). Power shift and power balance – working WITH the children, observe WITH the children (See role of the adult). 2 step questions require reasoning and own suggestions with the aim to solve questions – taking ownership and responsibility for Qs. Teacher and child learn together – relationships, trust, active observer, see children in a different light. Social relationships – learn about the children. Child led means they are not bored and doesn't have a knock on to behaviour.	P209 Serret and Earle curriculum coverage issues.
Prior knowledge	Relevant to individuals as it built on what they already knew. Related to home experiences, relate back to prior experiences (2 examples) and related to step 5 – higher order thinking. The children couldn't name plants at the start.	P90 Loxley. Benefits e.g. ownership
Thinking skills	Higher ordered thinking skills were evidenced as a result of child lead approach – naturally occurring. Authentic (does this involve more than just child led?). 32:40.	

Theme: role of the adult (brown on mind map)

Sub topic	Evidence / Interpretation	Associated reading
valuing	Valuing home experiences. Led by children's interests. Choices and own design. Providing a real-life context – including unexpected results, predictions that differed to the finding, opportunities to notice detail e.g., roots, lifecycle. Experience authentic science, reconstruct knowledge, address misconceptions. Compare, stimulated further questions, led to further enquiries, notice and address misconceptions. Develop a love for it (care for plants). Active observer – see the children in a different light. Learn together, relationships, trust. Looking back they remember, appreciate achievements, take time to reflect, social and time to learn about the children/each other.	P84 Serret and Earle Oliver 2006 – planning stifles creativity p211 observation assessment advice from EYFS
structure	Enquiry based approach – incorporated into every lesson. Not necessarily a whole afternoon. Learning cycle structure: Results led to new predictions from the enquiry hypothesis 28:34 Used a more flexible approach (before university seen as a ppt and worksheet or GCSE textbook) but now discovery (feel invested and inspired). Used scientific thinking skills to structure the outdoor learning. Clear objectives and success criteria. Inspire children to raise questions e.g., question stems, discussions, reflections to evaluate and consolidate. Was initially too teacher led (early sessions and learnt from this – prompting and spoon feeding, focused on learning and getting objective). Became freer and involved less prompting. Enabled them to question and discuss and 'play with it'. Allowed use of equipment, modelled, show me (flipped learning, feedback). Know where to take the learning next. Less rigid structure and safer to ask questions. Less confined. Involves self-discovery, outdoor discussion, inside more waiting and listening, look and work out puzzle, use children's questions to plan for assessment, enable children to find their own answers, time and speed of answers are different to indoors. When you remove the structure it is replaced by scaffolding and the children are invested in the purpose so behaviour is ok	Dunn and peacock p213. Assessment for Learning P72 Serret and Gripton structure
Assessment	Attainment 24:26. Knowing where the children were working (age related expectations). (They were discussed collectively with 2 individual examples) Observations of children were useful – able to see what they can do in an authentic way – can see their	p162 Dunn and Peacock Culture broker

	capabilities beyond the expected limits. See their progress and address misconceptions 1:05:20. There is a need for rich data on learning. It is easier to assess Working Scientifically outdoors – not invasive and aids children's confidence. (Why is it easier? Way of thinking?) Overall skills and knowledge. Assess their explanations and ability to make connections.	
planning	Provided resources, time and opportunity, not over prompt or encourage. Differentiation – highlighting insightful answer, pointing things out and encouraging, reflecting back, highlighting points of interest, revisit misconceptions and enable them to see adjustments and self-address issues. Plan for progression. Planning for the use of success criteria. Working scientifically in the planning, know expectations. Plan for opportunities – with an outdoor focus. Know where to start, timings, adaptations for age groups. Differentiation – no definitive answer, mixed ability pushed each other and bounced off one another. Read for the child. Develop breadth through follow on discussion, choices and comparisons. Plan for scientific skills and thinking scientifically e.g. use of key vocabulary, sorting and classifying, use keys & identification (understand how they know), matching, use key and identify, make connections, cause and effect, previous experience and explain. Plan for children's questions.	P38 Serret and Gripton Critical moments P7 Serret and Earle Behaviourism and constructivism, stand back, progression, prior learning
Teaching philosophy	Model enthusiasm, which rubbed off. Engage in discussion for stronger talk. Help them to make links. Model attitudes including curiosity e.g., through question generation and other observations. Questions were viewed developmentally. Adopted a working WITH them approach and observing WITH them. Not teaching from the front of the class – indiscrete teaching. (Power balance? Power shift?). Giving children more autonomy and ownership of the objectives and focus. Saw what worked in practice – adapt, unpick. Evaluate, extend. Allow children to speak (find their voice) and not butt in. prompt questions and ask for questions at the end. Reflect, think, talk, model examples, prompt, provide a simple format or structure to learning. Enable them to understand why they are doing it. ZPD – use of expert to explain differences and changes.	p203 Serret and Earle

	Notice attitudes e.g., willingness, independence, motivation, passion (overly positive due to novelty?), relaxed	
Manage	Prioritising time for outdoors. Initially thought hard to resource and manage. See the outcome as a reward (e.g., eat crop/shadow changes captured). Manage behaviour – reluctant to teach outside but behaviour was actually better. Preconceived ideas changed, stimulus to explore and observe meant they were engrossed in learning with more time on task than indoors. Can be seen as challenging e.g., different type of recording, live in the moment, chance for loss of focus, control, change of structure, spread out, feeling they may miss something.	P5 Allen – progression. Not linear nut hypothetical.
Thinking changed	Content and knowledge were the focus indoors with follow-up, activity and worksheet, demonstration and write up. The outdoor work has resulted in a shift in teacher understanding and indoor focus now involves planning own activities, choices, decision making. Outdoors focus more on promoting curiosity – different science experience. See and discover the facts. Focused more on higher order thinking skills. Not taught and write about what was taught. Discovery learning. Challenge of separating child learning and teacher learning New learning was taken on board and retained after the session.	Wood 1976 Problem solving and scaffolding p98. P22 Serret and Earle Brain science – connections P26 reasoning P171 creativity
Future goals	More children over a longer period of time. Explore how secondary sources can impact enquiries with stronger vocabulary and pre-knowledge. Pre and post learning conversations including how results changed. In NQT/ECT year will take this approach into the teaching of light – enquiry based, not necessarily the whole afternoon (initially thought this would be challenging and hard to resource and manage), classify and group sources of light. Potential investigation ideas to incorporate into every lesson. Enable children to see the rewards. Regular throughout the day. Evaluate findings and discovery. Further their reasoning. Incorporate their own suggestions to success criteria. Model and demonstrate ideas. Encourage children to ask 2 step questions. Apply to NQT/ECT year – excited and passionate about trying out with own class in Y2 (expect to develop this further).	

	Include less adult input, notice differences of working with and without peers. More focus on vocabulary next time e.g., promote the use of scientific vocabulary and language in context e.g. through a pre-teach. What is the influence of age? What would be the effects over time? (Impacted by placement length, school priorities/values and timetabling) Interested in a science co-ordinator role. All ages? Opportunities, make connections to the outdoors. Hands-on child led, sensory. Cross curricular, plan for children's questions. Promote participation.	

Appendix 15: Analysis of the children's questions

Coding key based on Jelly (1985):

- comm: comments as questions,
- philosoph: philosophical questions
- fact: information question relating to knowledge and naming
- complexA: questions where connections are made
- complexB: questions which involve reasoning
- investA: a question that tells you what to change (independent variable) and what to measure (dependent variable).
- investB: a question that tells you what to change, but you have to decide what to measure.
- investC: a question that tells you want to measure, but you have to decide what to change.
- investD: a question where you have to decide what to change and what to measure.

Coding key based on Bloom (1956)

- know: knowledge based questions why questions, stimulated by exploration, demonstrate curiosity
- comp: comprehension based questions
- applic: application questions
- analysis: analysis involves questions that relate to prior-knowledge or experiences
- synthes: synthesis involves questions that relate to findings
- evalu: evaluation involves questions relating to bigger concepts and may involve the scientific community.

shows where a misconception was identified.

Questions from the children within each case:

TR1:

		Bloom	Jelly
Cycle 1 Appendix 7	Why is this feather on the ground? What bird has this come from?	comp	complexA
	Why is the leaf brown?	know	fact
	Who bit the leaf?	know	fact
	Why is it a mouldy tree?	comp	complexB
	Why do they (leaves) fall off the tree?	comp	complexB
	Why is it so big (leaf)? What tree has it come from?	applic	investA
	Why is it growing from the floor (flower)?	comp	complexB
	Why does it look rotten in the winter?	comp	complexA
Cycle 1 Appendix 8	I found this feather from the ground. What bird do you think it is?	applic	complexA
	I think it is a small bird as the feather is very small, maybe a pigeon?	applic	complexA
	Why is it pointy (the leaf)?	comp	fact
	Why do they (leaves) fall off the trees?	comp	complexB
	What tree has it come from?	know	fact

	Why is this leaf brown?	know	fact
Cycle 1 Appendix 11	Why are we not finding any ladybirds? ** We are in winter, so do they (ladybirds) only come out in the summer? ***	applic analys	complexB complexA
Cycle 2 Appendix 9	How do birds build their nests? Why do they have nests? What sounds do birds make? Would the sound be small if the birds beak was small? How do they (birds) protect their eggs? Where do they (birds) build the nests? How do birds build their nests? Why do birds have nests? Question hand: What is the nest made out of?	comp analys comp comp comp comp know	complexB investA complexB complexB complexB philosop fact
Cycle 3 Appendix 10	I wonder why we found it (worm) under the rock? Can we find any more worms under rocks?	applic applic	complexB investC
Cycle 3 Appendix 12	Why can't we find any ladybirds? What if there are insects on trees? Why do they like to be really dug underneath the soil? I found this worm under a lot of mud, do they eat mud?	applic applic applic analys	complexB complexB complexB complexA
Cycle 4	How are we going to identify what insects like to eat? Will the mini-beasts like the sweet or sour foods, or the natural mud? Which foods attract the most insects?	applic analys analys	investA investB investA
Cycle 4 Booklets	How are we going to identify what insects eat? What do they prefer? Which food attracts the most insects? What insects come to the hotel?	applic applic analys applic	complexA investC investA investB

*** see how reasoning builds

TR2:

		Bloom	Jelly
Cycle 2	Why is it (magnifying glass view) blurry? Maybe we put it in a tree? Why do we need to give it a peep hole? ** How are we going to do that if the sticks are uneven? ** How are mini-beasts going to get in? ** How do the mini-beasts get in if they're all hidden under logs already? Why does the mini beast hotel need to look nice? Does this (pointing to the forest) look nice?	know know comp comp comp comp comp	fact comm complexB complexB complexB complexB comm
Cycle 3	Why is there a fly underground? What is that? Why aren't there as many mini-beasts?	comp know comp	complexB fact complexB
Cycle 4	Why does it smell like burning? What is that noise? Why is that so watery? Why are the bushes, leaves and grass different lengths and not all growing? What is this filled with water? (moss) (Talking about a sundial) How does it work? Is it like light and shadows?	comp know comp applic comp comp comp	complexB fact complexB investC fact complexB complexA

	Why are there no leaves on the trees?	comp	complexB
	How do puddles disappear? #4	comp	complexB
	What would happen if there was no sun?	evalu	philosoph
	Can plants grow on concrete?	analys	investA
	How does water get back into the clouds to evaporate?	analys	complexB
	#5	comp	complexB
	How do we get puddles?	comp	complexA
	How are mushrooms poisonous?	applic	investC
	How long do plants grow for?	comp	complexB
	Why do plants grow in mud?	comp	complexB
	Why do they get food from the roots? #6	comp	complexB
	Why can't they absorb (food) from the sun?	comp	complexB
	Why can you see water particles on the grass?	know	fact
	What is dew?	applic	complexA
	Why would it (the puddle) turn to ice?		
	What would happen if we took away the cold and it was really hot?	applic	investB
	What would happen if it was too hot and birds didn't	evalu	philosoph
	exist?	evalu	philosoph
	Would we still have eggs?	evalu	philosoph
	How were birds invented?	evalu	philosoph
	How was anything invented?	comp	complexB
	Why are these called flowers?	evalu	philosoph
	How does everything get its name?	comp	complexB
	How do birds catch their food?	comp	comm
	Why is the mud squishy?	comp	complexB
	Is a slug a snail without a shell?	comp	complexB
	Why does cardboard/paper rip when it gets wet?	comp	complexB
	(We don't slip with wellies on) Why?	comp	complexB
	(The fire won't light) Why?	know	fact
	What does water do to fire?	comp	complexB
	Why are there so many stinging nettles?	comp	complexA
	Why do leaves fall when no wind?		
Sensory hunt:	Child 1		
	Why does wet wood come off easily?	comp	complexB
	Why do flowers smell?	know	fact
	How do trees make paper?	comp	fact
	Who do they speak to each other by chirping?	comp	complexB
	Child 2		
	Why do birds chirp?	comp	complexB
	Why does rain fall?	comp	complexB
	Child 3		
	How do flowers grow?	comp	complexB
	How do birds sing?	comp	complexB
	How do trees fall?	comp	complexB
	Child 4		
	Why does dry mud turn into wet mud?	comp	complexA
	How does the flavour blackcurrant get into the flower? #7	comp	fact
	Why do birds sing?	comp	complexB
	Why aren't there many flowers?	applic	complexA
	Child 5		
	How does dew get on grass?	comp	complexB
	How does smoke travel so far?	comp	investC
	How do flowers grow?	comp	complexB
	How does wind howl?	comp	complex

Question hands	Child A:		
	What is friction?	know	fact
	Why do marshmallows melt?	comp	complexB
	How do flint and steel work? (to light a fire)	comp	fact
	Why do you have to save wood?	evalu	philosoph
	Why wasn’t there any leaves?	comp	complexB
	Child B:		
	Why are marshmallows so yummy?	know	comm
	Why does two pieces of metal make a fire?	comp	fact
	Why do marshmallows melt?	comp	complexB
	Why are eyes so sensitive?	comp	complexA
	Child C:		
	Why does metal make fire?	comp	fact
	Why do marshmallows melt?	comp	complexB
	What makes a fire?	comp	fact
	Child D:		
	Why do leaves change?	comp	complexB
	What makes fire?	comp	fact
	Why do you shave wood?	comp	complex
	Why does metal and metal make fire?	comp	fact
	Why do marshmallows melt?	comp	complex

* could be turned in to an investigable question

** procedural – focusing on actions

TR2 Booklets:

		Bloom	Jelly
Child M:	Why are trees so big?	Comp	philosoph
	How many trees are in the world?	know	fact
	Why do fungi grow next to trees?	applic	complexA
	Why do fungus get weeds?	?	?
	What other types of fungi are there?	applic	complexA
	Why do mushrooms eat trees?	applic	complexA
Child R:	Why do leaves fall?	comp	complexB
	Are mushrooms plants?	know	fact
	Why do mushrooms eat wood? #8	applic	complexA
	Where can we find fungi?	applic	complexA
Child I:	How do mushrooms grow?	comp	complexB
	Why are the holly leaves not dying?	applic	complexA
	Where is it (fungus) coming from?	comp	complexB
	Why do mushrooms grow in bad weather?	comp	fact
	Why are mushrooms different shapes?	comp	complexA

TR3 booklets: Session 1

		Bloom	Jelly
Child 1	Why do snails have shells?	know	fact
	How do plants grow?	comp	fact
Child 2	Why does snails have shells?	know	fact
	Who (how) is bark made?	comp	fact
	Why do we have daffodils in spring?	applic	complexA
Child 3	Why do snails have shells?	know	fact
Child 4	How do trees fit inside a seed? #1	applic	complexA

TR3 booklets: Session 2

		Bloom	Jelly
Child 1	Which way do you have to plant your bulb? How long does it take to grow a bulb?	applic applic	investB investC
Child 2	What will happen to my beans in the next few weeks?	applic	investB
Child 3	How does it grow? Why does a snail have a shell? *	Comp know	fact fact
Child 4	How long does a bean take to rot? Can we speed up the growth of a daffodil by putting it in the freezer? **	applic analysis	investC investA

* Repeated question session 1 and 2.

** type A (dependent variable – growth, independent variable - temperature)

TR3:

		Bloom	Jelly
Cycle 2	How are hills formed?	know	fact
Cycle 3	Why do some trees have leaves and some don't? Why do leaves fall off trees? What is the most popular tree on the field? Where do worms live? * How long does it take for a banana peel to decompose? How much rain fall is there in a week? How are hills formed? Do mini-beasts have different habitats? * What's the most popular mini-beast on our school field? Why do we have shadows? Why are shadows sometimes bigger? What plants grow from seeds and what plants grow from bulbs? ** How do daffodils grow? What animals will we find in spring? Why is the moon sometimes out in the morning? #2 Why is there frost on the ground? How do flowers grow where we don't plant them? How do fish breathe underwater? #3 What birds might we find on our field?	know comp applic know applic applic know know applic comp applic applic comp applic know know comp comp applic	fact complexB investB fact investA investA fact fact investB compleB investC investB fact investB fact fact complexA fact investB
Cycle 4	How long does it take for a banana to decompose? How long does it take for a banana peel to rot?	applic applic	investA investA
Cycle 5	Do bulbs only grow in the spring? Do seeds grow any time of year? ** Seeds can be carried by animals and wind like dandelions but can bulbs? Do bulbs grow quicker than seeds? Do seeds grow plants and bulbs grow flowers?	synthes synthes synthes synthes	investA investA investA investA
Cycle 6	Are ants the most popular mini beast?	applic	investA

* could be turned in to an investigable question

** comparison, connection and building on initial idea (Murphy 2020 in Gripton and Serret).

\# misconception

Appendix 16a: TR1 interview

00:08 Thank you for agreeing to be interviewed. You've got question 1, so looking back at the pre-interviews, how has your thinking changed? Maybe have a look through each of the statements that you made. Was there anything that you could add to that, anything you would change, anything that you disagree with?

00: 29 As in, in relation to like the question overall with like science and the outdoors?

00:38 Interviewer: yes…and what you said last time, you said 14 different things within the group and what your impressions were of science in the outdoors.

01:02 Oh yes, my initial reaction was, them going outside, they were going to be engaged. And that was obviously going to promote their questioning and how it was going to interest them with like discussion etc. But like it changed, my thinking changed in the fact that it wasn't always going to be focusing on their engagement and the content. I had to actually look into like the questions, how can I support children in getting that rich data of their questioning skills. I don't know if that makes sense at all really, sorry.

01:34 Interviewer: What kind of prompted you to realise that?

01:39 So in one of my, like evidence of like my observations, I was observing them and they were doing like a learning journey, of, around their woodland area. And they were picking things up but they weren't actually questioning and it led to me actually saying closed questions. They weren't actually able to expand on that so then I was just thinking oh, how can I inspire them to actually raise questions from what they are picking up rather than just because that is what I told them to do. 'You are going to pick this, you are going to go round and pick these things up in your nature garden'. 'what are you going to do?' like how are they going to raise questions from that?

02:17 And so then from then I did question stems so using question stems to help with them, with their thinking. Having discussions with children as well so before I just let them go outside and thinking, oh yes, they are just going to retain all of this information and then actually coming and having time indoors, sitting down in their usual environment and discussing with them what have you got from today etc. and then it allows them to think and like evaluate what they have been doing throughout the session. Is that alright?

02:52 Interviewer: Yes so, that reflection time must have been just as valuable as the questions then?

02:58 Yes, definitely, it especially helped with their erm recording as well, so their recording of the data that they collected. So sometimes they would come back and sit down and record into their booklets what they had found out. So, it showed to me as well, that they were actually retaining that information and it wasn't just you're going to go outside and you are going to do this. And they may look engaged but in fact they were engaged because that evidence in their booklet proved to me that they were.

3:34 Interviewer: So you said that the children were more enquiring and you said contextual learning was not just outdoors. Do you still agree with that now? Would you add to that? Is there anything else you would comment on?

03:43 Yes, I would defiantly still agree with learning was not just outdoors because they were able to retain that information from what they had learnt from the outdoors indoors and they were able to discuss what they had found.

03:58 I would also say how, erm, I still agree with they got more out of the children because they were more collaborative learning, they were learning together, especially children who were less confident, they were able to talk to each other, they were able to bounce off each other and it was able to extend their learning. So that more talk is involved so I still agree with the fact that that is very true.

04:20 Because you get more rich data from the discussion, that children feel more comfortable. It's weird how they feel, because you are gaining that trust with them outside and they are getting that ownership, so I still agree with that one. Number 8, there was more trust outside.

04:38 And like structure wise, there is definitely less structure, but you, I disagree with the fact that you are still allowed structure outside. You don't lose that structure, 'cos I was able to, like my questioning had developed throughout because I had seen that having that clearer objective doesn't mean, it doesn't escape as soon as you go outside.

05:00 Children are able to still have their learning objective, their success criteria and then gain their scientific thinking skills by thinking, raising questions and then evaluating through observations. Through their observations raising more questions and then consolidating them by investigating. So, they had that, that clear structure.

05:22 Interviewer: It's interesting, it's a different structure isn't it compared to what your indoor structure might be.

05:27 Yes, it is and I think sometimes that's quite, they need that because then it gets a bit too, too structured. You know what I mean they need that escape from like too much of the same. They need some new things for them to be interested in and develop their curiosity.

05:46 'Cos they never really used their outdoor nature garden and it was actually quite nice that you can get a lot more information from them when they, it's something new, and interesting for them.

05:58 Interviewer: Yes, and then you talked about ownership as well.

06:01 Yes, definitely. So I would say definitely, it allows children to have more of an ownership in their learning which I feel develops them confidently as an individual which then allowed them to become more curious and engaged in the learning so they became more independent. In a way allowing that ownership. They wanted to express themselves, they wanted to find out new things, they were raising questions. And then their questioning had developed because they were having that ownership and investigating.

06:40 Like, in one of my sessions, we were going outside, they raised questions from just their observing and then they came in and we had a discussion and then they were able to just, from what they had found out in the outdoors, they were then able to think 'oh I want to know this more' so then they were engaged. And allowing them to go 'yes, you can go and do that' they just wanted to do it and then obviously it extended their learning. They were finding out more things.

07:07 Interviewer: Do you think that lends itself particularly to science? Or do you think that would be relevant to a number of subjects?

07:21 Oh, you can definitely use that for many other subjects I recon as well. For like, especially with like, discussion allowing like ownership. Curious, you can link into like English, becoming curious, imaginative. Its like, I think it is, I don't know, that's quite tricky actually. Like it was related wholly to science because they were investigating etc. and recording data but then recording over time, that can link into maths, like recording data in graphs etc. And taking ownership of observing things over time and how they are going to record that. I think?

08:04 Interviewer: Ok and you did it with year 1 children, your actual data collection? And 4 children?

08:12 Yes

08:16 Interviewer: Ok, so if you want to change the screen, so question 2 is, what do the booklets or data collection that you have done show you?

09:21 So, this one here, this observation data allowed me to see, like, how the outdoors engages children. So like allowing them that freedom to explore and express their confidence and it supported their interest in finding, like here, they were looking at leaves and making stuff for like a micro habitat for birds etc. so they were raising questions and they were investigating confidently outside.

09:50 Which then lead them to then take a picture of what they had learnt even though it may not be exactly what a birds next looked like, but through discussion and being able to talk about it and then coming in and writing down what they were able to do and what they learnt from it. And so here it says like 'we were learning how to make a bird's nest to lay their eggs' they were using scientific language and they were able to evaluate and reflect on that discussion that they were doing in the outdoors.

10:21 So linking back to that ownership they were then able to discuss with their peers etc., supporting that engagement because sometimes it is interesting to like discuss whether they may look engaged outside because they're going outside, they are exploring the nature, but then it is interesting to see whether, are they actually learning from going outdoors, are they able to actually see, are they able to understand what they are looking at?

10:52 But then from the booklets, it obviously shows that they were then able to write down and record what they had learnt in the lesson and then why we used different twigs because there are different types of birds because of their beaks and different trees etc. and how they hold it together.

11:14 Interviewer: And in particular, how did you find the observations, was there anything, any specific examples that you could pull out of that as well?

11:19 In the observation?

11:25 Interviewer: Yes, you talked about exploration.

12:08 Yes, so here I, like through observations, I identified how, like, their body language suggested they were comfortable and that through like transcribing, I assumed that their engagement then lead them to be motivated to raise questions. Because it was then able to … they were bursting to tell one another what they had found out. So then they were raising what, why and how questions.

12:30 Which then sparked discussion. So then that's quite interesting to think of, like, from that they would then bounce off each other, collaborative learning, developing their communication skills which then allowed them to reflect on all that rich discussion to then conclude what they had learned.

13:00 Yes, so they were able to describe what they saw and what they did, that could relate to your 5 stepping stone thing 'I can describe wheat we saw and what we did'.

13:12 Interviewer: Yes, that links in well. Even slide 10 where you said about their ability to evaluate.

13:25 Yes, cos I have written in question 3, for the scientific enquiry bit, because there was more, they were able to like, they were observing, they were finding answers to their questions and they were then able to record them. Yes, so they were using their science experiences to explore with each other's ideas and then raised different kinds of questions from each other.

13:54 Interviewer: Yes, and that's quite high, isn't it, that's analysis isn't it.

14:10 Yes, and that would be 'applied' that raising their own relevant questions about the world around them because when they were observing they were raising questions because when they were observing they were raising questions and they were interested in that.

14:42 So like here as well, like this piece here from one of my observations, child B, the booklet helped to close that knowledge gap. So, it was like a learning journey for themselves. So, they were able to like raise these questions in their groups, in the, going outdoors and discussing. She wanted to know how birds build their nests and why they have nests. And then allowing that rich discussion with child C they were explaining because 'they want to hide from other animals that want to eat them' they then worked together to build a nest, construct, it like a bird would, so then this allowed them to close the knowledge gap. And then they were able to then again record that data and then obviously discuss it confidently. Then they obviously closed that knowledge gap.

15:34 Interviewer: So what do you think your involvement was to enable them to achieve this?

15:41 Myself? Well, I was more of an active observer in some points, like allowing them to just freely do what they wanted to do, but just giving them a learning objective of about birds, what do we know about birds, so like questioning them a little bit at the beginning, like, a little bit of input, me thinking about just, sort of like question stemming but not, its like prompting them to have that discussion and then just allowing them to like just play with it. In that sense and not having too much.

16:16 Because I noticed at the beginning, like it became too teacher lead. So just having that minimal like input at the beginning just to clearly outline like their learning intensions, like what, what do you want to like go and find out. So actually having that discussion from each other.

16:34 I also used question hands as well.

16:43 Interviewer: What do you believe was too teacher led and what made you think that?

16:46 When we did the learning journey sticks, as well, like when they were going round, like they were just picking things up and I think I was just too focused on… them learning, so like reaching that learning objective and like getting them to like ask questions rather than just thinking about, I was like prompting them to like say 'oh, let's start with this'. It was like spoon feeding them and I was thinking well this is just not working. It's just, like, they are not getting it because I feel like they just want to explore etc. So, it was just like coming back as an observer and allowing them to just, I don't know.

17:36 Like here in this document, I was allowing them to use equipment, having that ownership of the equipment, showing them what to do and then getting them to show me 'what have they found' so becoming like more, like 'where did you find this worm from?' 'I found it under a log with lots of mud' so then they came to think 'oh so are they all going to be under lots of mud' and then they were coming to think of investigable questions etc.

18:07 So it was giving them that ownership. Because I think that being too teacher led especially in the outdoors it becomes a bit too, I don't know, wishy washy like you are not, you are just forcing it on them etc.

18:23 Interviewer: So what are the codes here?

18:31 That's motivation, engagement, confidence.

18:37 Interviewer: Ok, so you analysed that through your data?

18:41 Child B asked how birds build their nests and they were motivated to know, 'I want to know why, how they build their nests'. They showed engagement because they were searching round and noticing why, so they were engaged to find out. Why, when, how they build them and where.

Then, that discussion with another child was then able to help them with that collaborative learning outside, building up discussion, explaining, where they were confident in explain to that other child how, like other animals, and then you are getting information from each other.

19:19 And then working together, they were motivated to then actually consolidate whether this was true etc. and them being able to be active in that, that hands on experience.

19:28 Interviewer: What's the bug hotel evidence there?

19:30 This one here was… so they raised their questions, this was one session, and I wanted to like develop their questioning, like skills, their question types (they were raising a lot of) what, why and who questions. So then there, allowing them to just investigate like mini beasts and like different insects in their nature garden.

19:56 They then raised questions of like, so if you, I said 'if you were to build a bug hotel for a worm what would you put in it?' [is a worm a bug?] and then from what they'd like found, they'd found worms, and then having that discussion, sitting down 'so where did you find those worms? In the mud?'. They then sat down and then they designed their bug hotel.

20:17 Then the next session, they built their bug hotel and they put in different foods to then observe over time. So they were having … we didn't actually get to do that at the end, because of COVID, they were actually going to observe over time what mini beasts attract to, but they put their food in and they built their bug hotel.

20:39 So from their observations and investigations they were then able to raise questions, investigable questions and draw out from what they had learnt.

21:03 What could you identify that might be evidence of thinking scientifically?

21:17 So from the question hand, this child raised the question from observing outside, so they asked the question whilst outside and observing their surroundings. So they were observing and raising questions from their observations and then through discussion and then collaborative learning, they were finding answers to their questions by working together. So 'what is a nest actually made of?’ they then went outside, went to go and actually see, had an experience of what nests actually looked like, how they’re actually made, discussing with each other.

21:50 And then from that, finding out those answers from their, like, simple raising of their questions, they were then able to record their data on their other question hands. So then, what is the nest made out of? They then found and investigated and then they recorded, so what is it made out of, they were able to record, like twigs, leaves and they stick it with their saliva etc. So, it shows how they raised their simple questions and then they investigated, observed and then they recorded their data.

22:32 And then raised further questions in light of that?

22:34 Yes, so we sort-of stopped on that one because I was like ok, we’ve got this. And then, erm, obviously from going back from this one [slide 4] to this one [slide 3], this session here, they were raising investigable questions. They were then able to go on to design their bug hotel and think ok, so I have found out this, I have found out where worms live, but then I want to find out… Why do they live there? What do they get from the soil?

23:05 So then they started doing their little, I have forgotten what they are called, where they put their food in their pots…

23:12 Choice chambers?

23:14 Yes, that’s it, they wanted to observe over time, so they were raising questions like that, thinking oh, ok, so, and they were able to design that from, like, I found this here but I want to know why, so observing over time.

23:28 Interviewer: It’s interesting that they are seeing, it sounds like they are really seeing a clear purpose to what they are doing.

23:35 Yes, they really actually enjoyed doing this because it was something that they had discovered and then they were building, like designing. I think they just liked designing their own bug hotel and being able to take ownership of that. And thinking I want to know why they eat this, why do they sleep here? Do they stay here in like different seasons etc?

23:56 And then having that ownership observing over time, giving them that, going outdoors and seeing what insects were in each chamber, it gives them like a purpose and it gives them like erm, it’s like observing over time is interesting for them because then they can record that data and gain more knowledge and then become more, like raise more questions, ‘oh, so why is this not?’ ‘Why has it not been this?’ ‘Because I thought it might go into this at this time, but it hasn’t.’

24:41 Interviewer: On the yellow grid on slide 10, I am wondering is there anything on there, in terms of ideas they are drawing on their observations and ideas to offer answers to questions.

25:00 Yes, they were showing curiosity about it, about the objects and they were beginning to like question why things happen and they were able to observe over time. I did do my own one as well, throughout this. I looked on this [slide 8] and highlighted and then on each child I wrote down how like they had changed over time like with their different questioning. So like child A: ‘Using their experience from observations in the outdoors to raise questions to help with their understanding. They were then able to draw out their experiences to find answers to their questions as they developed interest and motivation. And then working collaboratively with others and started to raise different styles of questions.’

25:52 Interviewer: So is that something that they did progressively over the time?

25:55 Yes, over the time because then I evaluated like the questions that they raised, their interviews, their answers, like one child would just, I would ask them a question, like what have you go there? A leaf. Why did you pick up that leaf? They weren't really able to explain. 'Oh, I just picked it up because I just picked it up' they didn't have anything, they weren't really curious about it.

26:18 And then having an objective, giving them that purpose of birds, like, 'Why do they have nests?', 'How do they build their nests?' and thinking yeah and I really want to know 'Why do they have nests?' raising that question and then being able to then discuss, going outside and observe and look how they do make it and being able to make it themselves, raises then even more questions so then they can think of…

26:45 Interviewer: How do you think that they achieved the higher order questions there?

27:00 The analysis ones?

27:07 Interviewer: Yes, and the synthesis ones, because you have got some there that are highlighted as synthesis and that is quite a high level.

27:19 Yes so here 'Identify further questions arising from their results' so whilst they were doing like their mini beasts, using the pooters, going outside, they were raising questions of where they found them, where they found them underneath. And then building that bug hotel, they were using the question stems that I prompted, to help with their like, so how can you observe over time, they then raised questions from thing like 'Why did the worms actually live under soil?' 'What nutrients do they get from that?' So, they were thinking deeper from what they had like found and observed in the outdoors.

28:00 Interviewer: And how do you think they could have achieved the next step?

28:04 Evaluation?

28:06 Interviewer: Yes, because what I am also interested in, the fact that this is year 1, and this grid here, for me is something that could be applicable all the way up to year 6 or beyond. I think it is really nice to see that year 1 children are achieving these things. How would you get them to get even higher?

28:34 Oh, I don't know

28:39 Interviewer: I don't know the answer, do you think that it is possible for children to be able to do it?

28:49 I recon it is definitely possible, I think you could easily. Its just allowing them more time I think as well. I think having more time and not having a set, do you know like, just being free with it. Having more time being able to like go outside and do things in relation to this and being able to actually observe them and think what is working and not working.

29:16 Interviewer: The other thing I wonder for that one might be, it says 'interpreted by the scientific community but whether they could do some kind of debate and convince people within the school. Cos rather than it being on such a big stage like you might have with A level, actually relevant to them and their scientific community, or even writing letters to companies like pest control companies or having a debate with people about how to control the ants around the school and you know that kind of thing would probably achieve that level wouldn't it?

29:54 Yes, that's true and haven't they got that bird watch thing as well where you can go online. That's actually quite good.

30:04 Interviewer: Yes that would probably enable them to meet those higher…

30:06 Yes, recording that data and then debate from what they had recorded over a period of time, they can then analyse. Sitting and analysing and discussing. Then coming to some sort of conclusion to debate their findings.

30:22 Interviewer: Yes and feeding data into a national data collection system. And understanding that value of that. Do you think they would appreciate that?

30:32 Yes, definitely, it helps with their communication skills as well, it's like an all-round benefit for their learning as a whole. I think it, like, it starts from reception really, being able to, like, go outdoors and discuss, like, the scientific thinking. Because then it builds on like their vocabulary, being confident in like discussing their ideas, their observations and its exploration.

31:06 Interviewer: So anything else on slide 10 that you would build on, you have got evidence for, so we have got scientific ideas, problems, evidence, predictions, is there also anything else in terms of thinking scientifically that isn't covered on there? We have got the bigger scale of working scientifically, but just thinking about thinking scientifically, or anything else that you have done that was scientific that was done outdoors that would be relevant. To be able to track, or document or plan for.

33:09 I added something to that document. I added in, like, different question types in the question section, but I don't know if that is relevant?

33:18 Interviewer: Yes, it would be interesting.

33:20 Do you want me to copy and paste this here?

33:48 Interviewer: Oh, yes, I remember you doing this.

33:50 Yes, I added in, because obviously my question was focusing on different question types. So like them being able to 'measure over time their investigations can help articulate their confidence to raise investigable questions to further their reasoning as they solve answers to why things happen'. And then this could then help their, like, using their ideas, they could model more than one step, so it could relate to using different questions to like model their ideas, because it could then help with their understanding and their evaluation of what they found or discovered. I didn't really think of anything else for the other ones.

34:36 Interviewer: That is really good because that is your area of expertise. Anything else on working scientifically that you would, or thinking scientifically that you would want to add to question 3? So question 4, this is your expertise. So how do you feel the children's questions changed over time? So this one might be the step diagram that might be useful. So maybe keep that in mind as you are unpicking it because obviously all of your evidence and all of the different strategies you used.

35:33 Yes, so at the beginning I obviously noticed children were able to raise what, why and who questions so through observing outdoors to having ownership again they were able to just raise those questions which I have got.

36:07 So the what here 'What are nests made out of?' and then they were obviously able to consolidate that but then I did notice how, erm, so relating to those steps 'I can remember what we saw and what we did', sometimes I noticed at the beginning they weren't really remembering what they did, like their questions weren't really allowing them to then come back and be like 'oh, I don't remember doing that'. So then I implemented the question hands so then they can write down their question hands, 'What question do you want to find out?' do your observation, do your investigation, go and explore and then answering your question.

36:51 And then they were able to see, this is what I asked and this is what I found out. So that was quite interesting for their confidence and their development in raising those questions. So then that obviously shows that they were able to describe 'what we saw and what we did'.

37:15 Interviewer: I guess they were sorting and grouping things, weren't they, in the task they were doing with the bird's nest.

37:29 Yes, and then they've got, like, their simple descriptions in their booklets of what they were sorting and grouping. Which obviously shows their, erm, understanding. So then from that I then went on to do more of a structured objective, which was obviously focusing on a micro-habitat.

37:54 But then I wanted to focus on not just what why and who questions, like how can I promote more investigable questions, like deepening their questioning skills for them to actually secure that reasoning, for me to then actually be able to realise do they actually know what they are doing, what they are investigating and why.

38:18 So then here [slide 6], they went outside and obviously with the pooters again. So 'What were you looking for?' so 'we were searching for insects and trying to find where they live' so this then led to them being able to, so using the question stems, this helped with that investigation, for them to draw out that bug hotel.

38:41 In their booklets here [slide 7], so this first section here, we went outside, so 'why couldn't we find any ladybirds?' so they were raising questions and I was like recording what they were thinking etc. And then discussing with each other deepened their thinking and then using those question stems and discussing together, with myself as well, so like having that reflection at the end of the session ….

39:32 Yes, so their questioning has developed throughout because they were then having that ownership in their investigation, allowed them to raise those questions of thinking 'oh so I know I found insects in this area of the nature garden so they must want to eat soil' [is that a question?] so they put that in their food chamber. And then they wanted to investigate whether they would attract to sweet stuff so they were putting oranges in that chamber.

39:56 So these question stems allowed them to think which one would they attract to the most. So, they were obviously looking at that observation over time. So 'Which one will the mini beast attract to in our bug hotel?', 'Will they attract to the soil?' because, and then they were raising like questions of, of course they were attracted to the soil because that's where they found most of them.

40:16 Then it allowed for that discussion of like seasons, whether 'Do other insects come out in the summer?', 'Do they prefer sweet stuff?' so like putting that in, which one do they prefer. Erm, and also, like, how could you design a new home for…, so from their insects it allowed them to think of, oh 'How could I design a new home for a worm?', 'How can I see which one it prefers?', so having like three different homes for it, so they were then able to investigate that and see and then over time they could then be able to record that data.

40:53 It would have been such a good, like, thing to see whether…

40:57 Interviewer: Something you can try out in your NQT/ECT year?

41:00 Yes, to be fair I have actually planned my Autumn 1 science and its about bug hotels and living things and their habitats. I'm really excited about that.

41:11 Interviewer: Do you think they found those question stems valuable?

41:15 Definitely, especially like, obviously for the year 1s though, I had to read it for them and like discuss what the words mean etc because sometimes some of them couldn't really read or, but to be fair I had quite a good bunch, I had a mixture actually. But they bounced of each other, they worked really well together and I think with science it's so good to like do it in mixed ability groupings, you don't have like your highers, your middles and your lowers because it just, I don't think that works. You are not like pushing each other, you are not getting that discussion and I think the question stems definitely allowed them to think, raise the question and then me suggesting so which one do you recon, they would, so they were like able to raise even further questions to investigate even further.

42:06 Which was quite nice for them to see, for me to see that like development in their interest and their engagement in that. So like in the booklet they have obviously designed their hotel and they were able to tell us about their drawing so it obviously showed that they were interested. So making a hotel for mini beasts and then what questions did you ask? 'How are we going to identify what insects eat?' So, then they were obviously going to identify 'how' insects eat by doing the three different chambers in them and what ones they attract to. And then they were able to like 'What do you still want to know' so getting that further investigation for them so 'What do you think they would prefer?' so like they were thinking, oh I don't know what they would prefer so I want to know so I want to observe over time and be able to record that data.

42:57 So that's actually quite nice for them, it's like a learning journey for them. And it was so nice to see that development from like their what why and who questions and not really understand why they were asking these questions to then having questions related to an objective, investigating it and then thinking further and deepening their questioning skills and then actually observing over time.

43:20 Interviewer: And that gives them more opportunities for that synthesis and evaluation doesn't it? I know you were evaluating session by session but they can get more depth in that can't they?

43:39 Yes, and then it could obviously go to, like, their evidence, like recognise scientific questions that do not yet have definitive answers, like they might observe and find something that is yet to be discussed, then they can be like 'oh, we found evidence of this' and then that could lead to a completely new, different investigation.

44:09 And then if you go to slide 9, so is there any evidence of step 3, 4 or 5 that you can see?

44:24 You know that 'I use what I already know to help me explain new things', so like from their investigation with pooters, like they already had that information and then in the next session they were able to use what they already know to then raise further questions to help explain new things. So like obviously doing the food chambers, they knew like worms were in soil so they knew that they would obviously attract to that but then they wanted to find out new things as to whether they might prefer other food in different food chambers. So, they were using what they had found out in the previous session to help them explain or find out new things.

45:08 Yes, and that's cause and effect.

45:16 Interviewer: You said they were using scientific vocabulary, are there are examples of that through each of the examples you were sharing?

45:23 In the booklet? Yes, they do, they use scientific vocab for the questions, I actually can't read that one, 'Which food attracts the most insects?' 'What insects come into the hotel?' I don't know whether their like vocabulary would be as, they haven't used that many scientific vocabulary for their sort of age but in some sense they are showing that they are thinking scientifically and they are raising, like, an enquiry of what they have found.

46:21 Interviewer: Anything else that you wanted to add about question 4, about how children's questions changed over time? Was there anything else you did to enable the children's questions to change over time?

46:36 I did erm, I used a concept cartoon, which I haven't actually put on there… but I did actually use concept cartoons.

48:12 Interviewer: Oh yes, I have not seen this.

48:15 Yes, I did this [slide 13] at the beginning and we discussed it outside so we were discussing what a bug hotel is. What insects, like, may attract to it, like what do they put in them. So then that was a good, and then linking to that question stems. I actually used them on the same time but the question stems produced more, more like data for myself in that sense.

48:42 But this was like a really good resource to use outside, I always find concept cartoons really good to use outside because then it stems their discussion. Which then, it brings out like questions that you don't actually think may come out. They actually raise questions by themselves and they think oh, even if it is like what, why or who questions, they are still valuable because then it leads to like further deepening and you can like use, go to investigable questions etc.

49:21 Interviewer: What did you do over your set sessions?

50:07 This shows like what I did in each and then I analyse in each erm step.

50:22 Interviewer: Yes this would be good.

50:24 Yes, so I did, obviously I noticed at some points, how like, 'cos obviously it was like questioning, I was thinking, oh none of them are raising questions, obviously at their like age as well it is quite tricky to like deepen their questioning types and ensuring that they are actually reasoning.

50:45 So obviously I researched and looked at like question stems, how they are important and how they support children's development in raising questions. Erm, and allowing that ownership and using concept cartoons as well.

51:05 Yes, like measurable questions as well. Yes, used concept cartoons as a warm up to encourage talk.

51:13 Interviewer: How did you explore measurable questions with them?

51:17 So that was what I wanted to do at the end. You know when they measure over time. What erm, so obviously if their food chambers, writing down in their booklets…this is actually what I am going to do with my erm class in Autumn. So that we are going to have like a class book and we are going to have, erm, each week and each day, going to the bug hotel, observing like what insects come inside etc. What do they attract to. So then being able to record that and measure over time.

51:47 So using like, erm, I have forgotten what they are called, independent variables, the different valuables, what would change, what would stay the same and like 'why do you think they would stay the same?' thinking about the weather, so its expanding on that.

52:13 And this is what I was going to do next. Observation over time would have been able to record those measurable questions.

52:22 Interviewer: Have you got all of the questions that you collected? Did you put them all in one place?

52:34 Yes, well I have got them all over the shop… I have got loads of question hands and loads of different…so I can just scan them in. I have annotated on them all as well.

53:00 Interviewer: Yes, that would be lovely, is there anything you wanted to talk about here in terms of those?

53:11 No I don't think so, if I think of something though I'll add it on, will that be alright?

53:20 Interviewer: Yes, that will be great. So, the next question, so is there anything you still don't know? That sort of links, I guess to your, you've done erm, you've done recommendations but were there any gaps, anything you still want to investigate more? So its clearly the long term data collection and doing it with your class over a longer period of time.

53:47 Yes, and being able to see whether you can actually get, looking at the erm, slide 10, the thinking scientifically document, so obviously discussing about like going into like that evaluation side. Being able to do that, how can I support children in that 'Explain how new scientific evidence is discussed', but how can I push them. Especially for year 2, because I am in year 2, it will be interesting to see over time how that can develop.

54:39 And also, I noticed how collaborative learning in the outdoors supports children's questioning and it would be interesting to see independently for children, like, do they get the same if they are on their own or having, I don't really know.

54:57 Interviewer: So something I am interested in is do children loose that skill as they get older? They are good at it in early years aren't they.

55:07 Yes, the interest, yes, really good, its like foresty schooly as well, it's quite nice that they can go into that and do, they like that, where as I don't know whether, like, going outdoors for like older children, that would actually be quite interesting, I would like to see further, if I could do, in my NQT/ECT time and do sessions with my class and then with like the older class. What do they think of it? And be observing them and seeing the outcome of it and why.

55:43 Interviewer: Yes, that would be interesting. If you ever do it then let me know.

55:50 Yes I will, I'll have to ask my erm, because we have got such a nice area that they try and tend to do it. Our head teacher is saying we have sort of lost that going outdoors, so it would be really nice for you to come in and be able to like use what you've been doing, 'cos he did his dissertation on outdoor learning.

56:41 Interviewer: Ok, so the next question, you have kind of answered, is how has your work on the outdoor learning in science inspired you to use it in your future practice, so you've kind of covered that already. Is there anything else you wanted to add that hasn't already come up?

56:58 It's made me more confident I think, as well, with like being able to like, how using the outdoors, because it is exciting for yourself and the children, it's interesting in a sense that you are in it together and building that trust and you are going outside, you are learning, you are becoming an active observer with them, so you're actually getting information for them. And you get to see like the children in a different light and being able to assess them is just interesting, I think, and it is definitely something that I would continue. I would definitely like to go into like doing science co-ordinating with like outdoors.

57:36 Interviewer: Do you think its right to assess children outside?

57:43 Erm, I feel like, it's like discretely, I feel like it's the best sometimes as well. I don't think, there's no right or wrong, I don't think. Sometimes it might be a bit too invading… I think for myself, for me personally, I assess children better through observation and I think outside it is easier to get that data, get in their discussion, them talking, seeing them in a different light where they become more confident, its actually quite nice to jot down not like a really big assessment but a discrete one.

58:54 Interviewer: I mean some of the things you've shared with me are invaluable things and you think some people could miss that if they are not capturing it.

59:02 Yes exactly, it's interesting, you think oh wow, this worked and then whether it could work for X, Y and Z or whether it would be different in this sense and you sort of just unpick it in certain ways and then you can like evaluate it further and extend it to see whether it supports this, supports that.

59:25 Interviewer: Do you think some teachers might find it challenging to assess in this way?

59:30 Yes, probably, especially, like, trying to like control children in the outdoors with like the noise etc, the wind, the weather, erm, loosing that structure, especially, me personally, I don't have such a loud voice like when I go outside I am quite like a, I'm not a shouty person, it's quite hard sometimes to like control that and be like 'were doing this'. And like assessing them, you might lose them a bit in a sense of you are trying to control someone over there and then you've got your missing data, like trying to assess children over there, they've probably picked up something and you have missed like that crucial discussion, that can be quite hard. But yes that could be quite challenging.

1:00:19 But then I feel like it is in, yes, it definitely is, because it's like there and then, isn't it and sometimes you don't really write it down as much as you would in maths. There's not things written down and it's there and then, it's not, it's like a live document, it's not, you can't really carry round a microphone to record all of the time.

1:00:44 Interviewer: Especially not with the wind and the rain. Ok and you talked about the different structure right at the beginning and how that structure is different to maybe teaching indoors to outdoors, so I wondered if you've got any recommendations for non-specialist teachers. And then my next question is, any recommendations for the course or my teaching? Just generally, outdoor learning but one thing I thought, that was interesting was the different structure, but is there anything else you would talk about in terms of that or other recommendations for non-specialists?

1:01:29 Erm, with the structure I would just say working closely with the children, like becoming, like being with them, observing with them, like not becoming, being more of like a discrete teacher, is that the right way of saying it, like don't be like you would be at the front of the classroom. Being with them, exploring in like the nature, being able to like ask questions, raising them together. 'Cos then that might build that trust and building that confidence to discuss with each other.

1:02:00 I recon that's, like that would support that structure in a sense, but you could then bring that in from, into the classroom, with more of a structure saying 'oh we just discussed this', do you remember what we did and having that question and answer that you would normally have in a lesson in the indoors.

1:02:25 Allowing them that ownership as well is definitely beneficial in supporting some structure because then you can say we are going to be observing this. You've told them that learning objective and then them going out and then observing it, taking ownership of them doing that helps with that structure.

1:02:51 Interviewer: And any recommendations for the course and my teaching?

1:02:55 Oh, I don't know. I don't feel like I can.

1:03:00 Interviewer: This is what I want, so anything that I have done with you or anything that you have done that you think actually year 3's would really benefit from this, anything that you found challenging that you wouldn't do next time, any tips?

1:03:20 Is it in like how to record like when someone says what they are saying, can you be like, how do I record that, how do I know, especially in the outdoors, if a child is discussing with you and they are saying certain things that you miss. I don't know what I am trying to say.

1:03:38 Interviewer: How would you record their talk?

1:03:41 Obviously I used, what are the called, speaker things and they had them round their necks and it went in but I could hear them and obviously it was recorded back. But I obviously used post-it-notes and erm being able to record on that was quite challenging of like the children, doing that. So how can, like, coding maybe I don't know, of like specific things.

1:04:16 So you mean like what you would be looking for as a teacher?

1:04:20 Interviewer: Yes, I think maybe mine is more on like thinking scientifically than scientific enquiry because sometimes I would look at working scientifically at their key stage and then think what they've said, oh does this relate to this, with like maybe some examples of talk that may come from in the outdoors that suggests that they're working scientifically.

1:04:58 Maybe having like more opportunities as well outside, going outdoors and being able to plan sessions that focused in the outdoors. Like how would you plan a lesson actually, that's one thing, in the outdoors, I didn't really plan, like, where do you start? Do you know what I mean? Do you start indoors or do you start outside, this what we are going to do, erm, yes, timings as well, of like...

1:05:35 Interviewer: Yes, how long these things take.

1:05:37 Yes especially with like your different age groups.

1:05:43 Interviewer: So my last thing, you know you have talked about working scientifically [working scientifically pdf], is there anything on there that you would add to in terms of that? Any comments you would make in terms of that? You were KS1 weren't you?

1:06:54 Yes like ‘asking simple questions’, erm, ‘use simple equipment to make measurements’, ‘I can compare things, I sort and group them’… I have definitely used them in, like, my planning I’ve referred to them. So like ‘performing simple tests’ and ‘asking simple questions’ and stuff.

1:07:55 You are able to see them working scientifically more when they are outdoors. I feel like I gained more information and understanding of children actually like succeeding in these bubbles because they are actually being able to discuss and they are actually going outdoors, where as indoors, I feel like you are not really, it’s harder to assess.

1:08:25 I don’t know that they are raising questions and then they are using the equipment to support them with that raising the questions and further investigating where as indoors I feel like they are there for them, they are not actually receiving that information or like taking that information in, because it’s just like there.

1:09:02 Interviewer: They have done a lot of that, haven’t they, they have been observing closely.

1:09:07 Maybe like scientific language, like how can you encourage young children to like use that scientific language correctly and in, like, the right context. ‘Cos I feel like they don’t really use or understand or know what language they should use when they are like quite young at that age.

1:09:42 Interviewer: So in terms of how much you guided them originally?

1:09:47 Yes, in the next key stage, they set up their own simple tests.

1:10:08 Interviewer: So, in a way the ownership has increased here hasn’t it?

1:10:10 Yes, definitely, like suggesting improvements and raising further questions.

1:10:30 Interviewer: And in a way you did a lot of those things. So ‘I set up my own simple tests’ but you did that as a group didn’t you.

1:10:36 Yes, where as they would probably do that individually [In lower KS2]. And like ‘suggesting improvements and raising further questions’ could also relate to them and their final section where they raised those questions when they were collecting like, the pooters, collecting those mini beasts. And they were trying to improve what they had done by raising measurable, investigable questions and finding that out to further their understanding. So they were starting to do that.

1:11:12 Interviewer: Yes, so that’s amazing, thinking that’s year 3, year 4.

1:11:14 Yes, science, it think, I had quite a good child. He absolutely loves science, and his mum used to do science with him all the time. He loves going outside and he’ll do like nature. Its actually quite nice thinking, like, especially in my school that I am at now, children do actually go outside and they build nests and they do things, where as I feel there is so much talk about this technology, that I feel like our generation now, especially like friends that I know that are like already parents etc. like hate children with tablets, hate them with like technology and stuff. Like they actually use the nature and outdoors. I thought that its nice that children are beginning to discuss that again. They haven’t actually lost it.

1:12:03 Interviewer: Yes, I think maybe that depends on the parenting as well though doesn’t it.

1:12:06 Yes, but its so easy, like, to just, you know and sometimes going outside is agg as a parent.

1:12:25 Interviewer: Thank you very much.

Appendix 16b: TR2 interview

00:16 Interviewer: I'll ask you the first question, so, looking back at the pre interviews how has your thinking changed?

00:28 Well, in terms of the behavioural problems [point 13], I'm starting to think, I don’t think that that is a problem outdoors, I think that's individual to the child. So when I said that, it was a child that can have behavioural problems anyway, I think it is more difficult to deal with outdoors because it is a bigger space but I don't think that the outdoors necessarily creates problems if that makes sense? If anything, I think they're happy and they enjoy the freedom because they’re essentially able to do, because it's child lead, they are not bored so they're not really creating behavioural problems... If you scroll, yes, that’s all the same. Yeah I think that's all alright I think obviously, there's just a lot more to it as well.

01:44 Interviewer: Yeah what do you mean by that?

01:47 So for example here I've said about progression in reasoning and scientific thinking but that goes into a lot more depth now, like you can clearly see where they started and what they're doing now. So, with the reasoning, I’ve said ‘linking to different contexts’ [point 23] you can see what they've already learnt is being thread through newer topics.

02:17 Interviewer: Yep, lovely thank you. So, the first question I've got is: what does the data collection that you have done show you?

02:38 So one thing that it shows is their curiosity. Yes, so it develops their curiosity and so they were asking questions all the time, I did that in the questions chart, didn't I, so it shows how often they are asking questions.

03:50 Yeah so here, they were asking questions, every single session we had they're asking questions mostly when they've seen and observed something or they are trying to explore something, which is why this session 4 was so high. Because we focused on sensory hunting then so when they physically touched something or were allowed to go and look at something they had more questions. Even when we looked at the fungi, I encourage them to observe it, we've got like magnifying glasses out, we did like a worksheet where they would label the fungi and ask all different questions because they got a lot closer to it they were asking questions like, oh ‘why are there these tiny brown lines inside the mushrooms?’. They found like orange fungi on the branches and they were asking ‘why there are different types of fungi?’ so questioning and curiosity was a huge thing.

04:51 Interviewer: What did you do on each of those sessions, so session 1, 2, 3, 4 and 5?

04:59 That is a good question, session one was a minibeast hunt, then we made a bug hotel, then I did like a research page, I can’t find it.

06:00 It was an exploration so they did like a habitat hunt, so they found different locations and they had a checklist, they had to find boggy ground, short grass, long grass, then anything else they could find so they found a mole hole and they discussed that. The second session was building a bug hotel, so they were given resources as a team to create a bug hotel. Session three was exploring the bug hotel, seeing which minibeasts had come to it, then they did a table with data collection, what they found, and then once they’d filled in what they’d found they said how they knew what they had found. So for example, I found a spider, I knew it was a spider because it had eight legs or something. Session 4 was the sensory hunt where they had blind folds, so they focused on their hearing, they were touching things, observing. Session 5 they did a sound investigation so that was very structured, very planned, lots of collecting and recording data.

07:26 Before all of these sessions, oh I don't know why I didn't put that session in there actually, because I also did types of plants, then we did the life cycle of a plant and then we looked at mushrooms and fungi.

07:57 Interviewer: So, it was interesting to see how those questions progressed overtime so I can ask you more about that one later. So, is there anything else from the booklets or from any other data collection that you can comment on, that you think was interesting?

08:11 Just generally overall, in general the skills and knowledge so they would, just obviously I've said curiosity, just transferable skills to anything so teamwork, independence, risk taking, questioning. Then also scientific skills, so they were using key vocab, so for example once they've learnt the word fungi, they would use the word fungi, they would use the word mini-beast, when they were sorting and classifying, they would say insects and like plants, trees.

09:29 They were able to use a key to identify plants so in the first… these are the first booklets [slide 4 onwards], so if I go to this one for example, they were using the key so they would find different leaves, they could explain what it was and how they knew. So, finding a Sycamore, they would be able to physically pick up leaf and match it to what they found, so 'I found a holly leaf using an identification card, I know that it is a holly leaf because it is spiky'. Not on here, but there was one, oh it might be on here actually, 'I found a daisy, I know it is a daisy because it is white'. I know it doesn't sound very scientific but these were the first lessons and for saying that at the start I think we could only get as far as, in terms of what a plant is, just saying that a tree is a plant or that plants have petals, so they couldn't actually name any plants.

10:43 Interviewer: Yes, so that's progression in itself, isn't it. What age were the children?

10:48 Year 3. Ys, so, using the vocab, questioning, making connections so it's not in these booklets, but when they did the sensory hunt and they just explored, cause the outdoor space was huge, so they just did a free for all and they found like a sundial. And one of the children asked what it was and then the other child described it and they were using words like light and shadows so bringing in other areas from their previous experiences and what they already know, to explain something to somebody else, using key vocabulary such as shadows.

11:42 When we were talking about the plants and the life cycle, they were able to sort of make cause and effect links which they couldn't do at the start, so saying that 'this plant is dying because of the seasonal changes and that they will grow again in spring because they will get more sunlight', for example, they were able to explain that, whereas before they didn't even know that plants needed water, air and sunlight etc.

12:17 Interviewer: Have you got that grid, the steppingstones grid, erm image?

12:42 Oh, that one yeah, I've got that I've put that on to my slides, I broke them down, shall I show you?

12:50 Interviewer: Because that relates to what you have just been saying there and the key examples.

13:00 Here this one, I made little notes, these? [scrolls through PowerPoint slides] Do you want me to go through those?

13:11 Interviewer: Shall we go to that question now? Or was there anything else you wanted to add about the booklets?

13:20 Just one thing was, that obviously we were talking about the outdoors, that we actually did a whole topic on the human body indoors, and just as a one off I took them outside to sort of draw around themselves, label all of the different body parts and we actually found out that they couldn't do it. They were drawing the ribs inaccurately, they were labelling things in the wrong places, so I think it just goes to show that actually, a different environment can bring different things out of them and is good for assessment. So, if I hadn't have taken them outdoors I would have just presumed that they knew.

14:00 But I suppose indoors you've got a lot more support, haven't you, because there was a display board with it, you've got the Interactive Whiteboard with things on. So, it's [outdoors] good for addressing misconceptions. And the last session we did, was birds nest so that was a lot of reasoning, application and convincing. I planted fake birds eggs which they didn't really buy at all. They were then told to make their own birds nests, so they made it with all sorts of different natural sources from outdoors and then, like what we did when Joseph came, we then made the nest, they sketched what they had done and they labelled why so we've put thin sticks around the edge for protection, we've done this in the middle for warmth, leaves in the middle for warmth, and things like that, so they were able to convince me that it was a good birds nest. Right do you want me to refer to these now?

15:09 Interviewer: Yes, you know in the transcript, was there anything there that was useful to this?

15:40 Yes, a lot of the transcripts obviously they are questions, so going back to the skills, I always forgot what I've found and then you go through it and it's like 'oh wow!'. They are looking at equipment so then knowing what equipment was used for, that was a big thing. So if you see here, just knowing what scientists did. So to be honest, before, I think I put this on the ppt with the booklets in like the unit of learning sheet, before when you asked what science was they just thought, they would basically say it was the human body because that's what topic we had been doing when they heard the word science. Whereas they didn't really understand what science was and what it was about and when asked about scientists it was like 'Oh yeah, they make potions', you know because that was their experience of scientists, that they have probably seen in cartoons, so then we focused on that a lot.

16:54 I would make it explicit to them as to what skills they had used. Then in this, this is session 2, I asked if they could remember the skills and they said exploring, collecting data, evidence, ideas. I asked why scientists needed resources and they said to plan and use equipment. So they were able to recognise scientific skills and looking back on my interviews as well from the first interview to the second, because we had been outdoors and physically look at the world around them, I suppose, they were able to understand, and when asked what science is, they could say more about the world and like plants, fungi, mini-beasts, weather, seasons, like they just had a lot more understanding of what it actually was.

17:50 Yeah so talking about protection, this is when they were making the bug hotel, explaining why they were doing what they were doing. So, decision making, that was another thing, so giving it a peephole, to look for predators, to be able to breath, there was another good bit somewhere here, so putting them under logs in the dark because that is where they found mini-beasts already, so using their prior experiences to make their own mini-beast hotel. And then one part, I can't seem to find it but where one child said about making it look pretty and then another child very scientifically rather than creatively said well look around you this doesn't have to be pretty, it doesn't have to be a pretty habitat it just has to work for what's needed, so make it more like the ground that is already there.

19:05 Interviewer: There are some quite advanced bits there for year 3.

19:11 Yeah there are, aren't there. They weren't the highest of abilities either. There was one boy who kept dipping in and out, so halfway through he said he didn't want to do it and then he came back. So, when they came back to look at the bug hotel, saying it was trashed, then thinking about why it could be trashed, so humans walking over it, the weather, moving the leaves gently because they didn't want to kill the animals, so I think just, what's the word I'm looking for, more environmental awareness as well I suppose.

19:55 Yes, thinking about where they had previously found them when they were looking, so where had they found them in their initial exploration. They were comparing what they saw now in their hotel and when we looked at mini-beasts the first time. So, saying why there may not be mini-beasts there, because it's cold in winter and they are hibernating so using that key vocabulary and linking it back to what I've said about weather and seasons. Just reasoning I suppose, so there was a lot of discussion and reasoning, so here, and even answering each other's questions but I think even if their questioning didn't change much just their discussion and answering of questions changed a lot.

20:50 Interviewer: I think that's so valuable and that you've been able to capture that in the transcripts. How did you manage that because I think a lot of people found that quite difficult to do?

21:00 What the questioning or the discussion?

21:02 Interviewer: Just capturing the discussion in the transcripts.

21:06 I do think I should have voice recorded, that's what I said I would do if I did it again, and I would take an additional adult with me because it's really difficult to capture everything so sometimes I would take the whole class, but that was really, really hard to capture everything. But when I just took a group of 6, it was a lot easier to capture. I'm a quick writer so my notes were really scruffy, which is why I typed it up, but just literally writing everything they say and just really focusing on them and what they're doing was really important. And I think because this was like a team task as well, like building the hotel because they built it together, they were then looking at it together, they tended to stay in one place for this bit so it was quite easy to capture what they were doing.

21:56 I think just letting them speak as well rather than constantly butting in, I mean it's necessary sometimes, but rather than constantly asking, just seeing where their conversation is going, then giving prompt questions, which is why I didn't ask if they had any questions right until the very end. But yeah, when you look back on it it's quite, like using the word hibernating and things. And one child asking what that means and another child being able to explain.

22:33 Interviewer: Yeah, even the quality of that discussion between children, even with you observing, is really strong. Did you get transcripts of other sessions as well?

22:46 Yes, so this next one is the sensory hunt, this is the one where they talk about, they have a lot of questions here, so this is where I feel like the questions started to change, so for example the first few sessions the questions would be not necessarily yes or no but almost one step so quite basic questions and then towards the end they would start to ask, sort of, cause and effect questions, so why is this doing this at this time? or why is this doing this because of this? And they would change, before they would ask very simple questions so why does this do that? or what is this? what is that? Whereas towards the end they started using vocabulary, so there's somewhere here where they ask about the puddles and evaporation and they never would have used that vocabulary at the start.

23:51 Interviewer: That's quite interesting because you know that steppingstone diagram that we looked at, so a lot of your evidence is the middle step like the third one along but where you've said that, that's the 4th one along. Because you're talking about cause and effect and that's clearly on there and then bringing in that scientific vocabulary is the 4th step. So that's quite exciting isn't it?

24:25 So here, that was just another time when I asked them what they know about science, so this was the 4th session and they could just explain everything, well not everything obviously but, they even linked like Coronavirus to science, like they understood that that's something that scientists work on and they try to find vaccines and medicines. So, they just had generally more knowledge like the water cycle, they could explain that that was science.

24:59 Interviewer: The water cycle is step 5 on the grid because that's applying sort of processes. But that's a massive change, isn't it, from the beginning when you started with them, when they couldn't name a plant to be able to show the links between those.

25:21 Yeah huge. So, this was it [ppt page 8]. This is where I was saying about the questions, so, before I think, for example, this one towards the end, 'why can you see water particles on the grass?', I think if that was in the first session they would have probably just said why is the grass wet, whereas they've started to use scientific language. So going from really basic yes or no or 'what is this?' questions going to 'how does water get back into the clouds after it has evaporated?' So even just the length of the questions is completely different.

26:02 Interviewer: It's quite sophisticated isn't it?

26:06 Yeah, why do they get food through the roots and not from the sun, so it's more, I want to say it was almost a two-step question. 'Is it like light and shadows?' so they're trying to make the connections themselves, it's almost like they want the information and they want to know how everything is connected. And I've put like reasoning and big questions, so, just like, I can't think of an example but, I don't know, just like really big questions that would lead to lots of different topics, like you could almost put it in the middle and do like a spider web from some of their questions.

26:55 Interviewer: Sort of linking to the big ideas? [Harlen, W. 2010 Principle and Big Ideas of Science Education. Hatfield, ASE.]

27:02 Yeah, and a lot of their questions changed depending on their experience. So I think when it was sensory and child led and they had a bit more freedom, they tended to ask more questions.

27:15 Interviewer: Yeah, it would be quite interesting to see those questions on a grid.

27:23 Yeah

27:25 Interviewer: So, I might work with you on that at some point if that's alright and try and put them all together to see specific questions overtime. If I do that and send it to you and see if there's anymore you can add, that could be quite useful.

27:38 Yeah, that's fine. Until last night, I'd not really even, like last night I was looking to remind myself what I actually did and when I saw the question about like the water going back into the clouds after it evaporated, that was like, wow, I didn't even pick up on this at the time.

28:00 Interviewer: Yeah it's lovely having the opportunity to look at these things with you, I guess in all the tutorials one thing we didn't do is just look at the data and that’s the bit that I love.

28:16 Yeah, I’m so glad I got a first.

28:16 Interviewer: Yeah, well done, it does prove that all of the stuff you've been doing with me over the year, you have really engaged with research, and that came through really strong because you really knew what you were doing.

28:37 Yes, it was definitely beneficial.

28:40 Interviewer: I think you were a step ahead of everyone so that was really good and a lot of hard work that you put in.

28:46 Yeah it was but it was worth it though.

28:48 Interviewer: Yes, ok, so if you go back up, so let's look at question 3, have you got the thinking scientifically grid as well.

29:00 No, but I’ll get it up on my phone. I've done all this work now and especially now I'm going through it I'm like oh wow I did do a lot.

29.45 Interviewer: Its nice to share it, definitely.

29.48 Yeah, uni does just feel like a distant memory, I think it's because we've started our jobs. Even on results day it was like, oh.

29:58 But right yeah I've got that one up then.

30.03 Interviewer: Ok, so it's just thinking about evidence of working scientifically, so maybe talk me through some of this and then bear in mind that grid that we have worked with in year 3.

30.11 Yeah, so I can remember what we saw and did and I can describe what we saw and did. So in my transcripts at the start of every session I would almost do a recap of what we did before so this was where they were able to say what they had done before in terms of scientific skills, so they could say ‘last week we collected data, we observed, we asked questions and we planned using equipment’ for example. They could say things like that.

30:45 They could also say the knowledge so, with the mushrooms and the fungi I took my 3 focus children like the booklet children out with me for one session on their own and we looked at fungi and then after that I took the whole class out to look at some fungi and actually chop up mushrooms and really look inside. And from taking them, those three out in the first session to then taking them out with the rest of the class, they almost became the teachers so every question that I would ask the rest of the class, they were able to then explain what fungi is, what mushrooms are and like compare the difference between fungi and plants and it was almost like yeah, like they became the teachers for the other children almost.

31:41 And that was the same with the mini-beasts and the habitats, so they were able to explain what they found, what they saw, so where they found the mini-beasts, what mini-beasts they found, different habitats, I'm trying to think of some more, let me look at the booklets.

32:01 Even just the first few sessions where we looked at the types of plants they all filled out, when we did the sorting and classifying, they all filled out a table where it had plants, ferns, mosses, trees, and they could all explain, every single child in the class, so 31 children could explain at least one thing that they had found and how they knew it was that from the classification key. So even one child said ‘I found hard Fern’ and they took a picture of it next to their key.

32:55 Interviewer: It's quite interesting, so in a way, you're talking about the knowledge there, but then you said that the whole class has managed to reach the comprehension bit because they were able to explain that to you and then I think also you've got the application because you've got those focus children who are then explaining and helping others so just within that one session you have managed to cover quite a lot of those objectives, haven't you?

23:25 Yeah, ‘I can use scientific words to explain what I think and say why I think this’. I suppose that will come into the, so we did the life cycle and that links to how they can explain, so we went through it, and obviously you can see that they've drawn seeds, they can explain that the plants grow from a seed and grows into a young plant, flowers etc and they could say that ‘it's winter so there aren't many plants’. They could make those links, but then they could also, if I find another example, they could also say about the leaves changing colour, why they're changing colour because they're dying. Yeah so here he said ‘changing colour’ and ‘the leaf is dying’ and ‘the leaves are different colours because they are at different stages of the life cycle’, ‘if plants don't have enough sun, water and air that's why they change colour’, and I think he’s put that means ‘its decaying’ so they have got some understanding of why things are happening and why there are changes. They even sectioned the leaves into like brown leaves, discoloured like yellowie, redie leaves and then green leaves, so they could see the different stages of plants.

35:20 Interviewer: It would be interesting to see what the next step would be for them.

35:26 Yeah, yeah that's true. Oh, what's next, ‘I used what I already know to help me explain new things’ [ppt slide 5]. That links back to the sundial with the light and shadows, so they had obviously learnt, or from their experiences they knew about that already, so they were able to use that knowledge to explain something to somebody else. There must be another example of using what they already know. I suppose in that final transcript where they are talking about the…

37:06 This is, yes so, if we're thinking about ‘what they already know to explain new things’, so when we did the sensory hunt there are a lot of like puddles and things and somebody asked how do puddles disappear, so somebody else was explaining that the sun evaporates it, so that is scientific knowledge that they have obviously obtained somewhere else and they're bringing it into this to explain.

37:31 Then we spoke about, yeah, one of the children was out of breath and I don’t think they would have acknowledged that as being science either, so I asked how it related to science and initially they sort of said ‘oh running and exercise’ so they were thinking about healthy lifestyle, and then when I prompted them to think about ‘why is she out of breath?’, they were able to say ‘oh she's run too fast’, ‘her hearts pumping fast’, ‘she's out of oxygen’. So, they could make those links. Then they went back to talking about the puddle, so I said what would happen to the puddle if the weather became minus 1 degrees, so I just thought I’d see if they could answer that and they were able to say that it would freeze, and it would turn into ice, because the particles change state; which was quite impressive.

38:30 Then they said what would happen if it was really hot and they were able to link that to like heat exhaustion, sunburn, hot countries, drought. They said because this was when it was happening in Australia, they said it would be like in Australia where they had bushfires and the plants and animals die because it's too hot and they don't get enough water, a spell of no rain is drought. So just making a lot of links with what they already know. Then they talk about the birds and how the birds catch their food. I think that’s it.

39:22 Interviewer: Again, it’s quite sophisticated the fact that they’re bring things from the news into what they're seeing when they are in school.

39:34 Yeah, because that was like when I asked what scientists do and they linked it to Coronavirus and then because somebody said COVID-19 they then started throwing out things like chicken pox and they were able to link it to like previous scientific research. ‘Use science experiences to explore ideas and raise different kinds of questions’ I suppose that’s what I just said isn’t it. They raised questions all the time and I think that, like the evaporation one and about the particles, that’s just using what they already know and their experiences. They still ask some silly questions I suppose, but maybe it's not silly but they're just curious all the time so like ‘how many trees are there in the world?’, or ‘why do the birds sing?’, ‘how do the birds sing?’. I suppose you could link that to sound then and the human voice. I suppose everything links to everything, doesn’t it. As soon as they saw something, they would just ask a question, I think it was almost like they’d got used to me saying ‘do you have any questions?’ that they just questioned everything almost.

40:59 Interviewer: I wonder why that happens more in the outdoors?

41:00 Yes this is what I've said I'd like to look more into. A direct comparison between indoor and outdoor, like I think it would be really interesting to do the same thing indoor and outdoor but I suppose you would never really be able to do that.

41.24 Interviewer: Yeah, ethically.

41.33 Yeah, I think these are all the things from the thinking scientifically grid that I’ve seen them do. So identifying differences, similarities or changes, they were able to do that with the life cycle and the leaves like I said, so identifying the different colours, explaining why, finding similarities, sorting and grouping objects when we did the first session with the types of plants, they were able to find different types of trees with their leaves, different plants, they found daisies they found a red Campion, I think they found one of those, making comparisons. I think I've already spoken about them but they have just done all of these things.

42:18 These at the bottom [lower 3 captions, ppt slide 7], I think the questioning was more than I ever expected, when I go back and look through it, so raising questions about the world around them, drawing on their experiences, questioning why things happened which is what improved throughout. So rather than just asking a question, they wanted to know more about the question, so ‘why is it like this?’ ‘Why does it do this?’, ‘How?’, rather than just asking what something is, and being stimulated by exploration.

42:49 And then this one is a massive one, just recognising the basic features, so like I said with the first KWL grids they couldn't say anything. I think as far as we got with plants was that they have petals whereas now they would be able to say about fungi, they would be able to list different types of plants, they would be able to explain how plants grow, the life cycle, so they've got a lot more information. So even saying leaves and roots, and they could explain how they absorbed water and nutrients and how they get their food, which they could never have done at the start. It wasn't as if I just spent the whole lesson just feeding them information either.

43:42 Interviewer: So, what do you think you did that helped them to do all of those things?

43:48 I think, obviously planning based on their questions so whatever questions they had in their KWL grid my planning went off their questions so I wasn't just teaching them what I wanted them to know but it was what they wanted to know and then any further questions we would try and discuss or they fed through. So I think just giving them opportunities to find answers to their questions and I think that goes back to like what you said about their discussions, so actually just letting them have a discussion, I think sometimes, I don't know, it's almost like in the classroom you feel like there's more structure and if a child asks a question and somebody else can't answer it because they're almost sat waiting. It's almost as if you have to get to an answer quickly, whereas outdoors you can sort of send them off and you can just have chats, you can send them to go and look at different things and see if they can almost put like a puzzle together and work it out for themselves.

46.00 Interviewer: Yeah, that's quite powerful. I'm going to share this screen with you. So its just want you were saying about working scientifically, I'm just wondering about, you've got all of the criteria but in terms of knowledge, comprehension, application, that side of it. Where do you think the children are on there [thinking scientifically diagram]?

46:25 Erm, probably analysis, erm, let me look at synthesis, yes probably analysis but I think if we spent more time on scientific evidence and different ways of presenting things, they could be further.

46:50 I think if I was to do it again, that's what I would do, I don't think I did enough in the moment assessment to progress them further.

47:05 I think at the time obviously I was doing everything alongside everything else on placement, I think if I was to do it again, I would focus more time on assessing like reflecting and assessing at the end because then I could have asked more specific prompt questions. Like I could have linked it, I suppose even when they said about Coronavirus, I could have made a whole lesson on scientific research and what actually happens and looking at whether evidence is accurate or what they think to the evidence because I think they would have been able to do that if they were given the opportunity, now I'm looking back at everything that they have said and done, I think they could.

47:56 Interviewer: It's kind of ground-breaking, some of the things they came out with and then it's thinking well, what more could be done. Would you say that's for all of them or some of them or… were there individual children that stood out for you or actually as a whole group did they bring each other on?

48:22 I think they brought each other on. There was one child who is definitely, it's difficult because I'd say they were all equal in terms of their overall skills and knowledge but there was one boy who was very good at explaining things so he was very good at using the vocabulary explaining and one girl was very good at the comprehension and the questioning and making connections. So, I think it is a case of them all just feeding off each other.

49:05 This bit with the strengths and weaknesses of models [thinking scientifically, problems, evaluation], I can't think of when they would have done anything like that. So maybe even more reflection from them, more self-evaluation.

49:25 Interviewer: I guess you've got The Water Cycle that you've already got in synthesis up here, that's quite an abstract idea, so you're already touching on that aren't you.

49:36 Yeah that's true.

50:04 Interviewer: Question 4, so how do you feel the children's questions changed overtime?

50:10 Yeah so like I said with the vocabulary, so going from saying ‘what is a plant?’, ‘how do trees grow?’, ‘what is this on the floor?’, ‘why is that there?’, it was more like 2 part questions where it needed more of an explanation rather than just being ‘yes’ or ‘no’ or a one word answer. And changing the terminology in the questions as well, so ‘why can you see the water particles on the grass?’ so like I said, if they had asked that in the first session or two they would have just said ‘why is the floor wet?’. To be honest even saying ‘grass’ is quite a difference. Yes, so going from just saying ‘what is this?’ to ‘how does this do that?’, ‘why do fungi grow on trees?’, ‘why not here?’ so ‘how does the water get back into the clouds after it has evaporated?’, ‘why do plants get food from the roots and why not from the sun?’. So just making like cause and affect questions or ‘why does it do this and not that?’. I can't think of another example but do you see what I mean?

51:30 Interviewer: Yes

51:32 So just making connections, rather than just asking what something is, that's essentially what it was at the start, ‘what is this?’, then making connections so ‘is this similar to this?’, ‘does it do the same as what this does?’ ‘is it like light and shadows?’ just making connections to different things.

52:01 Interviewer: If you go back to the questions bit, on the thinking scientifically grid, you can see under knowledge, it says ‘showing curiosity about objects and question what and why things happen’, and then the comprehension is ‘exploring the world around them and raising their own simple questions’, which they have done. Then it’s raising relevant questions which they then started to do didn't they? Then ‘new questions from the data’, so the things around them, looking at things that they collected, their findings.

52:44 I suppose in synthesis where it says ‘ask questions and develop a line of inquiry based on observations’, not solely on their own, but with the help of me, they have done that because they asked the question about ‘how plants grow’. And that was one of their big questions, ‘why are the leaves changing colours?’ so that did lead to a line of inquiry to look into the life cycle of a plant.

53:10 I think, this is what I said about my planning, like my planning was based off of their questions, because then when we found the mushrooms, they were like ‘are mushrooms poisonous?’, ‘are mushrooms plants?’. So those sorts of questions that led to a bigger…. it is almost like an inquiry isn't it, I suppose? And then ‘identify further questions from their results’, they did that at the end of every session, they would ask an additional question, even if it was only one.

53:42 Interviewer: I think also the fact that you gave them those opportunities, enabled them to make those higher, the ‘synthesis’ questions. It shows the depth of your understanding there. Are there any other examples of questions.

54:14 They did the question hands as well actually. ‘Why do marshmallows melt?’, ‘Why do 2 pieces of metal make a fire?’, I suppose you could go into a lot of those couldn't you?

54:57 Interviewer: Yeah

55:07 I almost wish I had done a table of all their questions and just picked them apart a bit more.

55:14 Interviewer: We could do that after this and I can put a few in from what I can find and then maybe we could have an email chat about it. Anything you can see just while it's in front of you though. Do you want to put those slides up?

55:41 Which ones?

55:44 Interviewer: The question hands. You might have to help me to interpret these.

56:16 Yeah, one of the children, he wasn't here for the question hands, his handwriting was really poor. ‘Why do metal and metal make fire?’, ‘Why do leaves change?’, ‘Why do marshmallows melt?’. They all wrote similar things. ‘What is friction?’, so that's interesting actually, because that just proves a lot, because when I first started the placement they were already learning about materials and forces and we did a session or maybe two or three sessions on friction and we did, I think we did two experiments on friction as well, yet outside they’re still asking ‘What is friction?’ So, they've obviously not retained that knowledge.

57:14 Interviewer: Or they are seeing an application for it in a different environment.

57:19 Yeah that's what I just thought, I did think that because obviously if they're talking about friction from the metal making a spark, whereas we didn't use that as an example when we were talking about friction, we spoke about shoes and different surfaces I suppose. Maybe that’s a good point actually, to consider different contexts.

57:43 Interviewer: Because that will make them question what they currently understand. So were you using flint's with them?

57:54 Yeah. This was when they joined Forest School.

58:05 Interviewer: So, was it 4 children? Was it 4 hands?

58:10 Yeah 4 hands.

58:11 Interviewer: Okay we will add it onto the question grid and see if we can add on a few more bits to that at some point. Okay is there anything else you want to talk about in terms of questions? You had a range of questions.

58:32 Did I, that's what I'm trying to find, you’ve got a better memory than me.

58:43 Oh good, it would be quite nice to go back and read it. I don't think you ever read your work the same as somebody else’s though.

58:58 Interviewer: No but you also tend to see all of your faults, which you shouldn’t but, I find it quite hard going back.

59:06 You almost just, I find myself just scanning through it again as well because I remember what I’ve tried to write.

59:53 Yeah so that’s them saying whether they prefer science indoors or outdoors and why. That was interesting because I expected it to be more motivation based, I thought they would just say, as children do, just say better, I thought they would just say it's better but actually they did give me good answers like ‘being with nature’ and ‘being able to talk more’ and ‘find real things’, ‘connect with the outdoor world’.

1:00:35 Interviewer: Its quite powerful that, isn’t it.

1:00:39 Yeah, very. Oh yeah this was the discussion that we were talking about earlier, this is when they were deciding where their bug hotel was going to go, so one suggested putting it on a bench near a tree, and they said no you can't put it underneath the bench because then flying insects can’t get to it and they can't put it in the tree because then other mini-beasts can’t get there. Then they said that it needs protection and they moved it into the forest and put it there and that's when they were talking about the holes and being able to look for predators and being able to breathe, and getting wood and sticks and leaves because that's where they found the mini-beasts before.

1:01:31 Interviewer: There’s so much reasoning in that.

1:01:32 Yeah, massively.

1:01:38 Interviewer: Do you want to have a look at page 21 and 22 as well. The number of working scientifically, scientific inquiry skills that they were talking about and then some of the questions in figure 7. I think you mentioned that actually about how they really understand more about scientists.

1.02.26 Yeah, this one, the skills before and after were incredible, so yeah before, like I said…

1:03:23 ‘What do you learn in science?’, so the red is what they said before so ‘how many bones do you have?’ I don't know, we do activities, experiments and ‘what's inside the body?’. So they didn't really know what science was other than ‘you do experiments’ and that they were currently learning about the human skeleton. Whereas after, they could say all of these things like ‘what scientists do’, ‘we learn new things’, ‘you learn how to make things’, minibeasts, humans, plants, sound, nature, about the world and just a wider range of topics.

1:04:04 The scientific skills, so how they think and act, what a scientist does in their job, that's how we worded it. Before they said ‘dig up things, find things, experiment, they are smart, mix stuff, make potions, look at computers. So even that going from saying they look at computers to then changing that to saying they research, so just changing the wording, so, they know what things are, they research, they observe, they question, predict, they test equipment, they figure out things, do secondary research, plan and collect data, use evidence, they discuss. We still got dig up fossils after but I suppose they probably do but it's more archaeology.

1:05:01 Interviewer: It’s what they are interested in. So, what do you think you did to enable this shift in their understanding.

1:05:14 Just spoke about it, made it clear, actually made them understand what they were doing, so asking at the end of a session, ‘what did they think they had done today that scientists do?’. So I think in the first session, because I had done this prior interview and I knew what they didn't know, in the first session at the end, I said what you've done today that scientists do is, ‘you have collected data’, ‘you have planned’ and I gave them some examples of what they had done so then further along, in each session I'd ask them what they had done that scientists do and they would be able to explain whereas I don't think they'd ever had that before, like they’ve never been told what a scientist does, they never understand…. and even, this one, this worksheet for our sound investigation in session 5, even just putting it simply for them like this in a format, where they know that they are predicting, they know that they are collecting data, they know that they are analysing the evidence and evaluating. So, I think just prompting them to think and actually giving them the words in the first place, so they know what they're doing.

1:06:31 Interviewer: It’s also quite powerful what you're saying about reflecting on their learning.

1:06:41 Yeah, definitely.

1:06:42 Interviewer: Okay shall we do the next question? Or is there anything more you wanted to add?

1:06:48 No I don’t think so.

1:06:50 Interviewer: Is there anything you still don't know? It's quite a hard one, I was wondering, maybe, what are your recommendations?

1:07:05 Yeah, I couldn't think of anything for this. I mean obviously there will be something that I still don't know, because I don't know everything, but I was trying to think what…

1:07:30 I was going to look at the types of questioning in more depth. I think from what we said today it would be, it was to do with that grid, the thinking scientifically grid. I think it would be to see how they react to real scientific evidence and models, and actually looking at the strengths and weaknesses. I think that's something that I don't really know yet and then just the direct comparison between indoor and outdoor. I think it would be interesting to do it again with a different group of children. But I can’t think of anything else.

1:08:50 Interviewer: Is there anything on there that you would share and use to summarise verbally what you would share with the children?

1:09:06 What do you mean?

1:09:07 Interviewer: So, this is like your summary isn't it of all of the things that you found. So, what kind of things would you pull out and share with people from that?

1:09:20 Just the changes, so I would just say that obviously questioning, reasoning, those things in bold, scientific knowledge, vocab, I’d just say that it improves those, that outdoor learning improves those. And like the skills for example, it brings those to the children’s attention and then the other side of that, is moving away from the scientific knowledge, is the transferable skills, so like first-hand experiences, independence, discussion, teamwork, increased talk, exploration, I think they are the key things.

1:10:06 Interviewer: And attitude was quite a big thing?

1:10:11 Yes so being motivated to…well, knowing now what science is and what scientists do but also being interested in that. Because I think before it was, oh no we don't do science, no, science is only fun because we do experiments. Whereas actually, I think if I was to go back in, even now, they would still say they like science, in fact, it shows from my interviews because I think initially they said ‘yeah it's good’, ‘it's alright’, ‘I like it’, and then at the end it was like ‘yeah, I love it’, ‘I’d want to do it three times a week’, ‘every day’, ‘as much as we can’ rather than just once a week.

1:11:06 Interviewer: So what you have done to inspire them is brilliant. So, did you want to go back and share question 6, so how has your work on the outdoor learning inspired you to use it in the future? So that’s a good point to talk about next year.

1:11:19 Yes definitely inspired me to use it again, so I have put, cos I often think that when you say outdoor learning or outdoor space they just immediately think early years or year 1. Whereas it doesn’t need to be just for yearly years or year 1. They think, even forest school, you can use forest school, I would definitely use forest school throughout the school and give all children that opportunity. Especially because if they have not been into like a forest area or woodland area they are not going to be able to make the connections the other children can. Because they won’t have seen as many things.

1:11:59 Cross-curricular benefits, so yeah, just using it for all ages, not necessarily just for science either, so English, if it worked, I would have taken the children into the forest area for things like creative and descriptive writing because it brings out that imagination and curiosity. Even just changing their attitude and motivation I think can make a massive difference. Supporting multiple needs so obviously it's very sensory, hands on, it can be teamwork or independent.

1:12:34 It motivated the children, I don't know if that was just because it was something different or if that would work all the time, I think it would. But I think the main thing is having that, being almost child lead. So, for example, planning from their questions, if they wanted to go and look at something then they could, they could investigate it, they could get a closer look.

1:13:02 Yeah just getting a lot more from them in terms of understanding, participation, being willing to talk, being willing to ask questions, I don't think I would have got as many questions in the classroom. I think it's almost less rigid and I think children feel like it's a safer place to questions, just because it's outdoors and bigger. I don't know it's weird, I don't know how to explain it, but it's not like confined. I think maybe as well, I suppose, they see the outdoors as like their relaxed space so maybe it relaxes them a little bit and brings out more of their social skills perhaps and transferable skills.

1:13:50 Interviewer: Its quite interesting you know when you're falling asleep, probably when your teaching, and just as you're drifting off all of these questions come into your mind and you have (like I was saying in the lectures, when you have a post it note pack next to your bed and you just write them down so you can remove them from your head), it's kind of what you're saying there isn't it, that as they are relaxing, the questions start flowing. I've not thought about that before.

1:14:18 Yeah, no I hadn't really, I suppose that's like their children zone, I suppose. Maybe that's why there was so much discussion when I just left them to discuss. Maybe they find it easier to discuss with each other in smaller groups than as a whole class or with an adult. Even though I was there taking notes they probably forgot that I was actually listening in.

1:14:52 Interviewer: So, in a state of relaxation?

1:14:53 Yeah, I'm hoping to create more of an outdoor space or improve the outdoor space at my school next year, so hopefully I'll be able to use it.

1:15:14 Interviewer: I'm sure! You're so inspiring, I'm sure you'll have lots of opportunities whether its inside or outside.

1:15:20 Yeah, I think as well, even if I don't get to make an outdoor space, I'll still go outdoors. I think that's the thing, you don't, obviously on my previous placement where I did all of this, I was lucky that they did have a forest area, like a really big forest area. But even still I think, just in a field like my school now has got a huge field surrounded by trees they've even got peacocks, not like school pet peacocks, but they just turn up, so there's so much discussion you could do just from that.

1:15:52 Interviewer: Yeah, totally, yeah just using the bushes…

1:15:57 Yeah exactly.

1:15:59 Interviewer: So, question 7, so with your new knowledge, what are your recommendations for non-specialist teachers? So, we've kind of touched on that with your poster but feel free to add anything else, and what are your recommendations for the course and also for my teaching? This is your chance to get your own back! Yes so any new knowledge or any recommendations for non-specialists?

1.16.42 Yes, just to use the outdoors, even if there isn't very much space, even if you have to take your own resources and almost plant them outside, definitely do that and use natural resources and space as much as possible. Every opportunity that you can, for example like, easy links such as plants, animals, weather, seasons, light, shadows, all of those are really easy links to make outdoors, so especially with those topics just go outdoors it makes it a lot easier. Look at different outdoor activities, like, there's so much online for different activities that you could find.

1:17:32 Oh yeah, I just think that outdoors you learn a lot more about the children. So there was this one boy who I sort of had as being quite outdoorsy, maybe I was stereotyping, but he was into his football, he was outdoorsy, so I thought that he'd really enjoyed going outside for science, because he tends to get a bit bored in the classroom, loses concentration, gets quite easily distracted, but actually when we were out there, even in his coat and his wellies, he would just moan that he was cold, he kept asking to go to the toilet because he wanted to go inside and that shocked me. I think you get to know more about their character and like the children that probably wouldn't speak as much inside can become quite chatty outside and vice versa. So, it's definitely a good assessment strategy and just getting to understand your children a bit more.

1:18:31 Interviewer: I wonder if there's something in there about investment and whether they are invested in the purpose. I thought the same before about my own children and sometimes they've had so much instruction that when you remove that scaffolding and that structure, they don't really know… like with football and tennis and cricket and all of the other sports that they tend to do, if you remove that structure, sometimes they feel a bit lost don't they.

1:19:01 Yeah, that's a good point. I hadn't really thought of that, yeah. It's very interesting isn't it. In terms of the course I couldn't really think, but I would say, as many opportunities as possible to work with the children, so we had, was it in second year we had the year 2's in.

1:19:24 Interviewer: It was the first year, it was the exploration workshops.

1:19:27 And then we had the year 5's didn't we, so even if you could make that possible for every year on the course, to have at least one, maybe even with different year groups, if that would work, I don't know if that would work. Just more opportunities. Or what I also said, was having it, you know how we've done this for you, well obviously for us as well but for us and you, it's been really, really beneficial so maybe not in as much depth, but if that could be a requirement of course, even to just try to do so many lessons outdoors and have a look at the impact, it might prompt more people to use it then. Like where we did the 'talk for science', we could instead of doing a talk for science or alongside, you could do science outdoors.

1:20:26 Interviewer: So, like a string of lessons.

1:20:27 Yeah rather than voluntary like what we've done, everyone is then focusing on outdoor learning in science and looking at the benefits or not.

1:20:37 Interviewer: I wonder if I did it what would I focus on, which were the most important bits that you got from it or that you thought actually this is the takeaway bit?

1:20:55 I would say the change in their personality in terms of more participation, and just like the questioning, knowledge and connections, so actually applying what they know to other situations and using the scientific vocabulary.

1:21:15 Interviewer: So, they could look just at those things within it?

1:21:20 Yeah because I think, like the talk for science, I think I did that and a lot of that was getting them to ask questions. Because we put something in a tin and got them to discuss, so even if they did a talk for science session and then an outdoor session and then see which one, which worked, I don't know.

1:21:44 Interviewer: Yeah or encourage them to, even if they did that talk session, encourage some people to do that outside.

1:21:51 Yeah, I think just making it.

1:21:54 Interviewer: Because they might get more from it that way mightn't they?

1:21:57 Yeah, I think so.

1:22:00 Interviewer: I think that's really inspiring, I'm going to press stop.

Appendix 16c: TR3 interview

00:00 Interviewer: Think about before you did your research, has your thinking changed? Is there anything that is different from when you started to where you are now?

00:24 Yes, so I think even looking back at placements where I've taught science - it's been very much like in the classroom kind of teaching the content and the knowledge and then children may be doing a worksheet or an activity like that or maybe me showing them an investigation and then them writing about it and then maybe a few investigations or enquiries here and there. I think it has changed from that to me being more inclined to get children to plan their own investigation. Putting all of the equipment at the front of the classroom and them trying to decide what they want to use and obviously the outdoor element was something that I might not have considered as much before.

01:10 But actually, I think that in terms of promoting questioning and like inspiring more curiosity for children. I think it's changed the way that I would teach science but also I think that it changes the way that the children see and experience science because it goes from them being taught [is this a reflection of her own experience?] the facts to them actually being the ones to discover the facts. I think that I noticed that there could be links between how they use the higher-level thinking skills in science but also they can link that then to geography or maths and things like that because its more them discovering things rather than them just being taught it and writing about what they have been taught about.

01:57 Interviewer: Thank you. Did you have any ppt slides that you wanted to share?

Yes

02:46 Interviewer: Is there anything else in terms of your thinking, maybe even before you started your research, did you have any pre-conceived ideas?

02:56 Erm, I think that I thought that it would be more difficult to teach outdoor in terms of behaviour and trying to manage the children because it was a different environment especially, not necessarily in the school that I carried out my data collection, but in schools that I had been in before, I would have been more reluctant with different classes to kind of take them outside.

3:25 Actually, what I found out was that actually the behaviour with some children is actually better than what it is in the classroom sometimes so I think that my preconceived ideas there changed because I think that the behaviour element wasn't a problem like I thought it would be because the children had so much stimulus to explore and observe and things, that actually there wasn't time for them to show challenging behaviour because they were just so engrossed in their learning, kind of thing, so I think that has positively changed and it's something that I'll probably not be as nervous about in the future.

04:07 Interviewer: Has your new school got any outdoor areas or any parks nearby?

04:13 It backs onto a park which actually has a forest school centre on it and then they also have an allotment. So, I am doing the topic plants and as part of that we go to the allotment and plant vegetables and then as part of D&T we cook soup.

04:31 Interviewer: You'll be in your element- that will be great!

04:34 I am really excited about that.

04:36 Interviewer: Ok, that's brilliant news, so number two, what do the booklets or any data that you have collected show you?

04:45 So, I first thought about how, like I said before, it stimulated curiosity by children being outside. This led to them generating questions about things that they had, erm, seen and even if it wasn't necessarily a question that was relating to the enquiry that they were doing on that day, they obviously were observing other things around them.

5:10 So children came up with questions, erm, I have got some examples. 'Why does a snail have a shell?' That was when we were doing, I think it was the decomposition enquiry, it wasn't related to that, but they had obviously seen a snail and come up with the question, 'why do snails have shells?'

05:28 So it kind of generated more questions erm being in the outdoors erm and the questions the children did ask helped me to address misconceptions. So, one of the questions, the first one, the child said 'how do trees fit inside a seed?' so that then showed me as a teacher that that would be something that if I had had more time and if I was actually teaching science for the rest of the year, that was something that we would need to kind of address.

06:02 And then the booklets also showed me that children linked their prior knowledge to the questions. They came up with questions that were linked to things that they already knew, so, for example the third question it says 'Why do we have daffodils in spring?' so the child already knew that spring was the season when daffodils grew which is like their prior knowledge. But they didn't know why that might be the case so they were kind of linking the questions to things that they wanted to find out but things that they also already knew.

06:37 I also looked at the scientific sketches that they made and the drawings that they did in their booklets. Erm, through this it showed me that the children were taking on board things that they had seen during their enquiry because on one of them we did classifying mini beasts and in their drawings a lot of them were quite accurate to the features that the classification cards tried to get them to notice.

07:06 Like, does the insect have 8 legs, that kind of thing, and then they had obviously thought about that and then when they were drawing, so like 'do snails have antennae?' and that sort of thing that we discussed in the sessions and then obviously the drawing of the leaf, they've kind of drawn it exactly how they saw it [consider misconception?] and then the insect on the leaf.

7:30 So I think they showed me quite a lot about their knowledge that they had gained and again – you can't see it very well – but they drew the lifecycle of a daffodil and then the beans that we'd planted. They took notice of the roots growing on the bulbs and things like that so the booklets definitely showed me that the children were definitely taking on board the things that they had observed and that they had learnt through the sessions and they filled those out afterwards so it shows that they had kind of taken that in and retained it a bit.

08:11 I thought that the booklets also showed that through outdoor learning the children made observations in a real-life context and this allowed for them to notice unexpected results. The child said that they were looking closely at a worm and there were more worms than ants. In their prediction they thought that there was going to be more ants so by being actually outside they were experiencing more authentic science so they were able to reconstruct their knowledge and their misconceptions were addressed.

08:50 Another child predicted that there would be ants but they actually couldn't find any ants and then that stimulated questioning about if they had carried out their enquiry at a different time then would they see different kinds of insects because where they were looking it was damp and cold and in leaves. So then they were speaking about how that might be were a worm would like to live but then where would other insects like to live. And in summer would there be these leaves on the floor and that kind of thing and having that authentic experience really helped them to kind of address their misconceptions and see it in a real-life context.

09:32 Interviewer: Its interesting how those questions led to a lot more talk as well.

09:36 Yes definitely, and I think… that really showed because in the first session when we just went outside and the children generated questions in the environment where we would be carrying out the enquiry and doing the research. A lot of the questions were kind of like… 'what kind of tree is this?' or 'why are there leaves on the floor?' and things like that. Then throughout the sessions the questions became more about 'do you think if we did this at a different time then we'd have different results?' or 'do you think that if we'd measured this then it would have led to something else, some other results and things?'

10:28 So, the questioning after they had done the enquiries definitely were higher level thinking questions rather than just the knowledge-based questions that they were saying at the beginning of the research.

10:46 Interviewer: so what age group was this with?

10:50 A mixed year 3 and 4. 1 year 4 and then the reset were year 3.

10:56 Interviewer: that could be quite good because you have got year 3 next year haven't you?

10:59 Yes

11:00 Interviewer: so that could lead in quite well, even taking those questions as starting points and seeing what they come up with. That could link quite well to next year couldn't it?

11:10 Yes definitely.

11:16 Interviewer: ok, shall we go onto the next question?

11:17 Yep

11:18 Interviewer: Oh actually, you know when you were talking about questions, we might come back to that one later. That could be quite useful. So, question 3, what could you identify that might be evidence of thinking scientifically?

11.36 Erm, so I have used …the speech bubble and this is focusing more on sorting hand grouping and simple descriptions. I have thought about observation and classification together and children use observations to identify, classify and group living organisms to establish the most popular mini beast on the school field. So when the children were doing this I gave them classification cards and magnifying glasses.

12:06 The children said that they didn't know what some of the mini beasts that they found were at the beginning but because they had been given the classification cards they were able to sort the mini beasts into, and use a tally chart to say which ones they had seen. Every time they saw an ant they put a tally on the chart. Their knowledge grew during that session because they, at first, they didn't know what some, I think they'd seen a, I think it was an earwig. They didn't know, none of the children could actually identify it. But when they had the classification cards they were able to look at the features of the earwig and then classify it and then obviously record their results. They actually spoke about that in their evaluation of their enquiry.

13:04 They spoke about how, because they had the classification cards their enquiry was more accurate because they were able to accurately identify and group the mini beasts and again because it was in a real-life context it enabled the children to actually find the mini beasts that they might not have known. Had we been in the classroom, looking at mini beasts in a different context, then if they had to draw them or had to label them they might have only stuck to the ones that they already knew like the most common ones maybe.

13:42 But actually being outside and being able to see different mini beasts it enabled their knowledge to grow because it was an opportunity that they might not have had in the classroom.

13:58 Interviewer: it's interesting what you said about the classification cards increasing their accuracy so must feel quite proud that actually you've enabled that by the resources that you've given them and the focus that you had, cos you obviously had certain expectations.

14:14 Yes, so I didn't give them the classification cards at the beginning because I just wanted to see what they already knew, kind of thing, but then I had them with me. I actually hadn't thought about taking magnifying glasses and then before we went outside a child said 'oh we've got magnifying classes in the science cupboard' so then I sent one of them to get them and then they were all using the magnifying glasses and the conversation that the children had when they found this earwig, they were like ' I have never seen it before, I think it's got pincers' and they were trying to identify it.

14:47 They were all giving their opinion of what they thought it was and then one of the boys was comparing it to something that he had seen in a film or something. That's when I gave them the classification cards and then they were able to together- and that generated more conversations as well because – one of them counted the legs and the other one was like 'no, no that's not right, we need to count it again'.

15:11 So that actually encouraged the group work and the problem solving between them. Two of them said 'I'll do it and then you can do it at the same time and we'll see if we get the same answer'.

15:26 Interviewer: that's scientific!

15:28 Yes, because they obviously thought that the more people that think that there is more chance of it being that, kind of thing, so that was quite interesting that they were doing it independently and then coming together to compare their results and, that wasn't even, I didn't tell them to do that, that was something that they just thought would be useful for them to do.

15:50 Interviewer: That's lovely to hear, it's very interesting, it's kind of like an early years strategy as well with you being led by the children's interests and you've been listening to what they want to take with them and what their resources are that they are interested in as well – which is quite interesting.

16:08 Yes, that was something, again, that I thought about afterwards. That, going back to what I said at the beginning, that offering them, even getting everything out of the cupboard and putting it at the front of the classroom and letting them tell you which equipment they want to use for their enquiry. Because I think sometimes, if you are doing an enquiry or an investigation, you kind of give them everything that they need and then that prevents them from designing their own enquiry or a different enquiry to the one that you were expecting them to design.

16:41 So I think that's something that going forward I would definitely try and encourage, like, the children to pick their own equipment because I probably wouldn't have thought of that – the magnifying glass thing – but they actually all used them and they were able to make closer observations through using them.

17:02 Interviewer: Yes, that's really good. I am just thinking, on your ppt here you've got one of the bubbles. Have you got the bigger picture of that? I am wondering, obviously, that's where you feel they are at. Is there anything you can show that shows the next step up?

17:38 I did have it open.

19:22 Interviewer: are there any examples of the higher-level ones, based on what you have been saying?

19:33 I think the next one up – the cause and effect, they can explain what they thought – I think because they spoke about how 'if they had done this enquiry at a different time then they might have seen different results' then I think they have definitely started to think about that.

19:57 And then they started to use scientific vocabulary because in their booklets they spoke about how they'd learnt to classify and group mini beasts, and things like that, so they picked up that vocabulary from doing their enquiry and also maybe if I'd have had time and they'd been able to do another enquiry, maybe, I don't know which tree is most common on their school field then maybe when they were planning their enquiry, rather than what they said about the mini beast, where they said, which is the most popular mini beast on the field, they might have then used that vocabulary to talk about classifying the trees on the field or to find out which is the most common.

20:54 Or maybe their knowledge would have then, from that enquiry would have developed their future planning of enquiries.

21:04 Interviewer: there was one you said where somebody was talking about the daffodil, what was one of the first questions that you shared?

21:17 Why do daffodils grow in spring?

21:24 Interviewer: Yes, it was one where you said that it linked to their prior knowledge.

21:28 Yes, about the daffodils in spring.

21:30 Interviewer: That was quite interesting, that even links up to 5 doesn't it? That fifth step.

21:36 Yes, I think I have put that one in on the next slide.

21:45 Interviewer: ok, yes, show me the next slide.

22:10 So, in this one I looked at the cause and effect, the descriptions and simple explanations. So, children noticed relationships between living things in their environment through using their pre-existing scientific knowledge and linking it to the findings in their enquiries.

22:32 So from the practitioner reflections, after their enquiry, children discussed how the popularity of different mini beasts may change due to the weather or seasons. That was a discussion that they had about, I think it came up because one of them said 'what about when we get lots of daddy long legs' and then we spoke about, 'oh, what season might that be in?' and the children said 'well we are allowed to on the field so it must be summer' and then we were talking about 'what other insects have you seen on the school field or on your garden in summer?' and they were saying well there are a lot of wasps and bees so they were kind of linking that to what they had already experienced.

23:18 And then, again children compared and ordered pictures and sketches so they got their photos or their drawings and they compared them and spoke about what lifecycle the daffodil would have been in during that time.

23:50 One of the girls said that because we planted the bulbs after the first frost then the bulbs might not grow and then she spoke about whether she could put the bulb in a freezer before she planted it and whether that would stimulate the growth of the bulb. So, she was kind of designing a new enquiry I guess.

24:14 Interviewer: did you say she was a more able child in the classroom?

24:19 Erm, I think she was probably at age related expectations but I think she had a lot of experience, I think that she went out a lot with her family, like she was saying that her grandad had an allotment. So, I think she was quite scientifically minded because of the experience that she might have had outside of school. In terms of English and maths and things she was probably kind of in the mid-ability group.

24:49 It did come across, the children who had had the experiences at home as well in terms of relating their knowledge that they had seen back to things that they had already experienced or created predictions based on things that they might have already seen if they were going on a walk or if they were in the garden.

25:07 One of the children had said that he was panting bulbs with his grandma in her garden and she said to him you have to plant them a certain way up for the roots to grow [we had discussed this misconception from a teachers point of view]. So, he had linked that to his experience and he was sharing that with the rest of the group. So, it definitely did show the children that has had more experience in the outdoors. They… were able to make more like scientific predications I guess, I'd say.

25:45 Interviewer: Yes, lovely, thank you.

25:49 And then this one is looking at the predication skills, so erm, I put about the children used, again, their pre-existing knowledge so 'I used what I already knew to help me explain new things.

26:06 One of the children said that the banana peel would decompose and compared that to mouldy bread that they have seen in their bread bin at home. So, they were talking about how they had seen …they said it was furry and blue so they were kind of predicting that that's what would happen to the banana and again they said that it would go fluffy and mouldy after 3 hours so they were kind of using what they had already seen – bread go mouldy and a banana decomposing.

26:45 The predications meant that misconceptions could be addressed, because the children spoke about how, erm, going back to the mini beast enquiry they thought that ants would be the most popular but that might have been because they were thinking of a different season.

17:15 So that allowed conversations to happen about 'what might be the reason for ants not being popular, even though you thought they might be' kind of thing.

17:32 Their results often raised new questions and predictions based on what they had already found out in their enquiry so going back to what the child said about the bulb and could you put it in the freezer and then maybe that would speed up the growth, 27:49 Again the mini beasts, what about if we'd repeated this enquiry at a different time then would we get different results. So, they were kind of, evaluating their enquiries but also they were kind of making new predications and had new hypotheses based on their results that they'd found out from their enquiries.

28:15 Interviewer: How did you feel when they were achieving those higher levels?

28:20 Yes, good because I think… it was very child led, I didn't really have that many expectations about the progress that they would make. I knew that… I would hope that they would make progress in their scientific skills and things but because I didn't know what they were going to find and what they were going to observe and actually the things that they saw, I might not have even seen myself.

28:49 They were picking out things that I've not even thought of, kind of thing. So, it was good that I kind of had to be ready for any conversation because I wasn't leading the conversation, it was more of them leading it. So, it felt like it was more the fact that I'd provided them with the resources and also provided them with the time and opportunity to go outdoors.

29:19 But in terms of my teaching, I didn't necessarily feel like I was having to prompt them or having to encourage them to use those higher-level thinking skills, it was just something that really, I felt like, was happening more naturally.

19:34 But then I think it was the environment that they were in and also the time and me letting them lead the learning, which actually lead to that. So I was amazed at what they actually, the progress that they actually made because I don't think I was expecting it to happen kind of authentically as it actually did because I didn't feel like when you are normally teaching them, sometimes you have to really think about who is learning what and what are you going to ask this child and what are you going to ask that child and how you might use different questioning for different children, whereas actually in the outdoors I felt like I could have asked all of the children the same question and they would have all given me different answers but all of the answers would have probably been just as insightful. It was really interesting that it didn't feel, it didn't feel like it was really difficult to help them to make the progress that they made.

30:39 Interviewer: Do you think there might have been something that you did naturally because you had obviously taught them for a whole term and then you were doing individual or group lessons. How many children did you have when you were doing this?

30:49 4, well I had 5 in the research but one of them did his guitar lessons so I didn't get any data for him. He was in the kind of group but then I realised after that he had his guitar lesson and he wanted to still do it so he would come for like a few minutes and then leave.

31:11 Interviewer: I just wonder what were the things that you might have done naturally, that you didn't realise you were doing?

31:22 Definitely pointing things out to children or kind of encouraging them to, so if I heard a child say something and I thought that could be really interesting for all of the children to talk about I'd kind of say 'oh, what did you just say?', 'oh, that's really interesting isn't it?', 'does anybody else have any thoughts about that?' so I guess I was prompting them like that.

31:50 And also… when they did have a misconception, instead of me saying 'no that's wrong', I'd kind of say, 'oh so let's see what happens' and then at the end I'd kind of come back to it and say 'so do you think that that's, do you still believe that what you said was right at the beginning?' and then they would kind of say 'well no, because we saw that this happened'.

32:11 Like when we were planting the trees… and one of the children said how does a tree fit in a bean, erm, seed, I said to the child after we had done the enquiry ‘oh so how do you think the tree does fit in the seed then?’ and she was like ‘well it doesn’t fit in there, it grows’ so she’d addressed that misconception herself, kind of thing, without me saying at the beginning, ‘well no that’s not right like the whole tree isn’t actually inside the seed’ but then through the enquiry she kind of addressed that herself.

32:47 I guess I was kind of prompting them and obviously providing the resources for them to be able to do it but it felt like the children were very enthusiastic and maybe my enthusiasm as well, that might have helped them because I was quite excited about their enquiries and maybe that kind of rubbed off on them.

33:20 Interviewer: Yes, definitely.

33:24 And then, I just used this quite because I thought it was quite interesting, that the children said that they couldn’t plan an enquiry from the question ‘how are hills formed?’ because it would be impossible [is that the case?].

33:40 So again, on the first session, one of the questions that they came up with was ‘how are hills formed?’ and I just wrote down all of the questions and then once we’d actually looked at enquiry and the skills and the stages that you go thorough, and things, one of the children said we can’t do that because it’s impossible. So, they obviously progressed in being able to decide like researchable questions and also kind of understanding what kind of things they could do an enquiry about and what kind of things that they may struggle with - doing an enquiry about – or that would be, kind of, impossible for them to do.

34:27 I thought that was quite interesting that they could identify the researchable questions.

Recording paused.

37:20 I wanted to speak about the evaluation skills, so kind of linking to what I was just saying about them being able to make new predictions or think about they might change their enquiry if they were going to do it again or how they could make it more accurate or reliable.

37:40 So, the children spoke about how they wanted to see what happened to the banana peel decomposing through a certain amount of time. In their plans of their enquiries they said that they were going to see how long it took for the banana peel to decompose but then in the thing that they were going to measure, it didn’t link to… so they needed to measure the amount of days it was going to take but they didn’t do that they just observed it over a certain period of time. But then after, they evaluated their enquiry and they said that ‘we could see how the banana changed’ because obviously they had observed it over time ‘but we should have recorded the days to make our experiment more accurate’.

38:35 And then when they planned their next enquiry with the bulbs and beans, they then planned into their enquiry that they would observe how the plants change over time and then that’s when they thought about how many days and what happened over that time period.

38:55 So I think that their evaluations actually helped them to plan future experiments and enquiries because, they kind of thought about, well that didn’t work last time so how could we do it again to make it more accurate, so I think that that was something that definitely helped them progress in their actual planning enquiries and like working scientifically.

39:25 I wanted to say about the children using synthesis to make predictions based on their knowledge and understanding. So again, I said about the bulbs growing in spring and them predicting that seeds can be carried by animals and wind like dandelions but bulbs cant - so again they were, kind of, again, using their prior knowledge.

39:58 And then I have kind of like circled the things that I think that they have done that I have kind of spoken about. Like, the knowledge from the beginning really, they were doing that, so they were asking questions before we had even spoken about the skills of enquiry. So, in that first session before we actually thought about enquiry, they were asking questions just based on their own curiosity and things that they could see in the outdoor environment.

40:32 Again they were recognising basic features, so before I gave them the classification cards, they knew kind of what, that they were having to look at how many legs it had or does it have antennas? Does it have wings? Those kind of things but then after giving them the classification cards, it moved to making comparisons based on the living things. So, it can't be a fly because it doesn't have wings or those kind of things. Or like even, kind of, talking about vertebrates and invertebrates and things like that so it definitely progressed in terms of that.

41:20 And then they responded to suggestions from evidence and they were making observations, so in the decomposition experiment they were making observations and that obviously then progressed because they started their scientific sketches {clear focus on thinking scientifically objectives in the planning?} and became more accurate or they were obviously observing it closely because they were looking at more, like smaller details and things like that rather than when they were doing the decomposition, the details that they saw weren't as kind of detailed and then they were responding to the evaluations that they were making.

42:02 And then obviously they were drawing on the experience in the first few sessions and kind of linking it to their pre-existing knowledge or things that they already knew but then, actually, that kind of became a skill that was developed because in the beginning they might have kind of said 'oh, well I know that dandelions are dispersed by wind' but then towards the end, or to the end of their enquiry, or later sessions, they were kind of using the knowledge that they had learnt to link that back to things that they already knew.

42:48 And then kind of testing whether what they knew was right or wrong and coming to a bigger kind of, I don't know, making their results based on more, I guess like, they were explaining how new scientific evidence is interpreted by the, that kind of links to what I was saying about them working in teams and 'if you get the same answer as me then it might be right' and so they were using like more evaluative skills, the higher order thinking skills because they were, they kind of realised that actually if we all got the same result then there is more chance of it being reliable because everybody had got the same result… rather than them just kind of drawing on experience that they'd already had.

43:36 So, like well, somebody's told me this so it must be right. They are actually saying, well, it depends on how many people have kind of got the same result kind of thing. So I think you could see the progression from the knowledge to the higher order thinking skills.

43:56 Interviewer: You talked about how it started earlier with knowledge and then progressed over time.

44:02 Yes

44:04 Interviewer: So, would you say it was linear or was it still a bit abstract as there were a few things from analysis coming up earlier.

44:11 Yes, there definitely was, like for example what I said about the bulb and ‘could we put it in the freezer’ that was… I think I said that they end their dormancy after the first frost and that child said that as soon as I’d said what I’d said, she said ‘oh, well we have already had the first frost so maybe they are not going to grow but we could do this…’ so she was obviously using those skills before kind of, it wasn’t like she started on knowledge and then throughout the time got to evaluation. She kind of used knowledge and then, at the beginning, and then she’d also used other skills so I think that it wasn’t as linear as they start using knowledge and then it progressed but I’d think that it was, you could definitely see how it started as the lower order skills and then you saw more evidence of the higher order skills as the time went on, kind of thing.

45:28 Interviewer: Was there anything more that you wanted to add for question 3?

45:31 I just put that [working scientifically pdf] in because I was just looking at it and I was thinking about how, using the outdoors lends to all of, like, the opportunities to do most of these things like exploring the world around them,

46:20 Interviewer: Its really nice seeing all of the circles that you put on that because it really brings it out to you of where they have really achieved those objectives.

46:40 So, I was thinking about how it lent, the outdoor element, lent itself to the opportunities so the first session that we did, we went outside and the children just came up with questions that they might want to make enquiries about in later weeks but also it allowed them to get used to the environment kind of thing.

47:07 So they were able to raise relevant questions and then having different experiences and again they started making decisions about the types of enquiry - that was completely child led. They decided which enquiries they wanted to come up with and how they were going to design their enquiry and what they were going to measure and all of those kind of things.

47:37 I was just thinking, there was one that I thought that, it was about how they can use ‘ask people questions and use simple secondary sources to find answers’ that was the one that I thought about using the secondary sources, potentially is not a skill that could be taught as well in the outdoor.

48:17 Obviously they can ask other people questions and that is something that I saw happen a lot but I think, how potentially, pre-learning and post-learning in the classroom could have been valuable in terms of them finding out about what is already known about something either before or after their enquiry and then comparing their results to that.

48:40 Or being able to design potentially a more accurate enquiry because they’ve already found out, they’ve already found out the common, or like the scientific phenomena about that thing so it might have been helpful for them in terms of when they actually design their enquiry.

49:00 With the lifecycle of a daffodil, I actually printed off the lifecycle of a daffodil to give it to them because I felt that without that kind of secondary source or without that knowledge beforehand then their enquiry probably wouldn’t be as successful. So that’s something that I could obviously print off and give to them whilst they were outside or whilst they were planning their enquiry.

49:25 But it might have helped if they were in the classroom and they could have read books or they could have used the internet to find out what’s already known before actually planning their enquiry so I thought that was something quite important that if you are doing outdoor learning then there is still a place for like the traditional classroom because actually that probably would have helped them write up their results more accurately maybe and kind of plan their enquiries potentially more accurately as well. Which is something that I did find.

50:00 Interviewer: What I love is that so many of these things that you are telling me, you just to naturally.

50:07 Yes, it's something that you don't really think about, isn't it.

50:23 Interviewer: So how do you feel the children's questions changed over time and I know you have addressed that in a lot of what you have said.

50:31 I think the main thing, was like I said at the beginning, was that the questions started off as the more knowledge-based questions. So, kind of, asking the teacher or asking me 'oh, what kind of tree is that' or 'why do we have shadows' and things like that, that could have been answered, like I could have just told them an answer too at the time.

51:00 But then actually I think that they realised that they could find their own answers to those things through enquiry so they stopped asking questions like, well the knowledge based questions, and I found that they actually started asking more questions like, and not even so much to me, they were more directing questions at each other so they were asking more questions like 'oh, well what did you find?', 'how many insects did you find here' or 'are our results the same?' and those more higher order questions. And also I think it was the questions that, that I think they realised that actually they could find out their own questions but then it was more like 'is what I found out reliable?' and they were asking questions about what they'd found more than what they wanted to find out – if that makes sense?

52:16 Interviewer: I am just going to show you some of your questions. Can you see that? So those are the key questions that I collected from your booklets. I just wondered if that helps you?

52:38 Yes, so… I think that they're the questions that the children kind of had at the end of their enquiries but I think some of the questions, as well, during the enquiries, so you can see that like 'can we speed up the growth of the daffodil by putting it in the freezer?' like we talked about or 'what will happen to my beans in the next few weeks?'. I feel like they're more questions based on what they'd done rather than some of the first set of questions where it's like 'do snails have shells?' or 'how do trees fit inside a seed?' so you can kind of see it a little bit within those questions.

53:34 Interviewer: Yes, they are why questions and again that's something that is not really investigable, whereas these are a lot more focused, aren't they, as you said?

53:45 Yes, I didn't really think about it like that. Yes so again, 'which way do you have to plant your bulb?' was a question that one of them had and then we had a conversation about it and then another child spoke about how they'd done it with their grandma and she said that you had to plant it this way and then I think later when we'd had a conversation we'd said that it might have been a good enquiry that they could have done 'does it matter which way you plant your bulb?' kind of thing, had we had more time to kind of do that.

54:18 So I think that the question were more based on, the questions in session 2, you could've kind of used more in the next steps, in a way, to kind of consolidate their knowledge and also it would have led to, I imagine, more learning about bulbs and about beans and things like that. So, they were more focused on what they actually had learnt that time rather than when they were doing the first session and some of the questions were a bit more random about what they had kind of seen during the sessions, so like snails having shells and how is bark made.

55:01 There isn't more random questions, that obviously, they had seen a tree with bark and they wondered how is bark made. Whereas in the second session it is more based on what they had done that session and what more they wanted to find out about, the learning that they had done.

55:20 Interviewer: So the next question is, is there anything you still don't know, it's a really hard question, so you don't have to answer it…anything you think you don't know or would like, in a way, what would you like me to find out more about or what would you investigate if you had the chance to do another study?

55:53 I think I would be interested to find out, like what I was saying before, because we did enquiries about for a different question each time, I think I would be interested to see how for example if you took a question about, about how long does it take for a daffodil to grow, and then using the questions that came up from the enquiry, to plan a new enquiry and then the questions that come up about that to potentially plan a new enquiry so kind of to use their results to try and plan another just to see how their knowledge changed from the first enquiry to the last enquiry.

56:36 Interviewer: You'll have to do that with the allotments won't you?

56:43 Yes definitely, and then I think, as well, like I said about using the classroom as well because obviously the time was limited and there was only a small group of children but whether I think in the future, kind of using the outdoors alongside the classroom to kind of see if the enquiries are using those secondary sources and books and things like that to see what impact that has on the planning and the carrying out of the enquiry.

57:15 Because I think that some of the children might not have learnt that year or they didn't have as much knowledge and you could see that they struggled more planning their enquiries because they didn't have as much subject knowledge or they didn't have as much pre-existing knowledge about it so I would be interested to see how if you kind of taught them in the classroom and then you planned the investigation or enquiry and then you came back to it in the classroom and kind of wrote it up and discussed it, how that might have changed, the conversations or the results that the children were kind of getting.

58:04 Interviewer: How has your work in outdoor learning in science inspired you to use it in your future practice? You've already told me that before we interviewed so did you want to talk a little bit about that now?

58:10 Yes definitely, I think it's definitely made me think about the way that I will teach science. Even from my first science topic, it's light, so even thinking about that, when I've looked at the planning and things I have tried to make it as much enquiry based as possible and even, even like before I think I was more, I thought of an investigation or an enquiry being like taking like a whole afternoon and being quite like a more challenging thing to organise or plan but actually now just thinking about, well what about classifying or grouping objects that are reflective and shiny or sources of light.

59:03 So that's an enquiry but it's not as how I imagined it before as being like, you have to have a question to prove it or disprove it and you're going to have to have loads of materials and resources and it will be quite a big thing even just like walking round the classroom and classifying an object as is it a source of light or is it reflective or those kind of things, is definitely something that I have tried to incorporate into every single lesson and using the outdoors.

59:36 So thinking of when, with light for example, thinking about shadows and investigations and enquiries that I could potentially use for that and also, try to, instead of just having an hour of science, thinking about we'll go out in the morning and we'll draw chalk around a shadow and then we'll go out even every couple of hours of the day. It doesn't have to be just one lesson and everything has to be done in that lesson so I think it's definitely changed my approach to teaching science.

1:00:17 Also, interestingly, I think I had the impression, even in the first year or before starting uni that science like, your teacher would be stood at the front and maybe show a ppt or a video or something and then you would do a worksheet and that kind of thing but actually it's kind of completely changed my like vision of science because it's actually way more about kind of the discovery of facts and knowledge more than you just learning them.

1:00:46 Because even when I was doing my GCSEs I just learnt the text book off by heart and, that was the way that I learnt science all the way through school but actually I think that if I'd have learnt it how we were taught it at uni and how I would try and teach it now in my teaching then I think I would be a lot more, I would have been a lot more invested in science and inspired by it because that didn't come until uni for me.

1:01:15 I didn't really, not that I didn't like science, but I didn't really think of it as being how I think of it as being now. I have just thought of it more as like learning facts.

1:01:22 Interviewer: sounds like you are going to inspire a lot of little learners that way. Have they got data loggers? Because that will be brilliant for light. You could be doing some measurement for the higher end.

1:01:43 I'm not sure, I'll look into it.

1:01:47 Interviewer: What about your allotment project that you are thinking of?

1:01:51 I think its Spring 2, I'm not sure, but I have not actually even really seen or, since my walk around, I've not seen the allotment because obviously everything was like cordoned off and there were only certain places that you could go. But I think definitely, even like with growing the bulbs and the beans in that enquiry, the children just loved growing things and I didn't really get to see the reward of actually growing it because everything happened and we had to stop the going into school and things but I'm really excited to be able to see it growing and the children looking after that, taking care of it and going every week to the allotment and then them actually being able to pick it and eat it. Because I think that will be really exciting but I need to properly look into what I'm kind of doing because I've not thought that far ahead yet.

1:02:57 Interviewer: you are planning to eat it in DT aren't you? And cook it?

1:02:59 Yes, we will be making soup so that will be good.

1:03:06 Interviewer: Ok, so with your knew knowledge, what are your recommendations for non specialist teachers and what are your recommendations for the course and my teaching?

1:03:16 I think for the other teachers, using that child led approach and kind of letting children go out into the environment and having that like, I feel like children have a lot of curiosity and want to know why and how things work and what's happening. So, kind of inspiring that by taking them outside and then them being able to plan and design their own enquiries is definitely something that I think is important because I do think that a lot of the time the teacher will plan the enquiry or the investigation and give them the resources and then the children will carry it out and write it up.

1:03:55 But actually I think they are a lot more invested in it and also it kind of, I think sometimes you lose that curiosity as you get older, but if your teacher is allowing you to still have that and encouraging that, then maybe more children will be curious for longer. And I think a recommendation would be just not to be like scared of going outdoors because that was definitely something that I kind of thought, well the weather or the behaviour or I kind of thought about excuses for not doing it sometimes. But actually, the children learnt so much not just in terms of science but in social skills and communication, those kind of things. So, I think definitely just not being afraid of going outdoors.

1:04:50 And then I think as you go into KS2 you kind of stop those observational assessments of children but actually I found that that was so useful and that's something that is definitely useful in science. Just being able to, while the children are doing an enquiry, just going round and actually just observing them and taking notes of the questions that they are asking and the things that they are doing because that's a more authentic assessment of them and also it really shows you what the children are capable of, that you might not actually have even thought that they would, the questions that they'd be asking, you might not have even thought about them yourself kind of thing.

1:05:29 So I think that was something that in terms of assessment in science and kind of seeing the progress that children made using observations of children carrying out enquiries, because as well, it shows you what knowledge they have and allows you to address the misconceptions that you might not of kind of thought of in your planning. And then you can obviously address them in future planning or during that lesson.

1:06:00 Then in terms of the teaching on the course, I really enjoyed science, I thought that it was really inspiring. I really enjoyed when the children came into uni because I thought that sometimes when you are on placement, it depends on the school, but you don't always have the resources or the outdoor space. So, I think, when they came to uni that was really good to show that this is what you can do at school and even if you don't have the space it's still possible.

1:06:23 And the equipment and things that is available definitely like being able to…I can't remember what is was called, but when we were doing the cars on the ramps and then we were measuring the speed [friction], yes, in some schools you don't have equipment like that but its good to know what equipment is available. Because if you ever were like a lead of the subject or something then that is something that you could obviously look into.

1:06:51 Interviewer: Data loggers again! Get some data loggers when you get the job!

1:06:59 I did actually really enjoy the science on the course and I found it really interesting and inspiring. I don't know what I would recommend. I do think that it was, I think that the outdoor element was obviously inspired me along with other things like being on placements and things. I can't…

1:07:26 Interviewer: maybe it's encouraging more to be done on placement in terms of science? Maybe we could work with schools on that?

1:07:30 Yes, because I think, when we did the core files and we had to have evidence of like science teaching in them but I found that like maths and English were like really thick, which obviously is going to be because you teach them every single day, but then the science was thinner and I think I asked to be observed teaching science but it wasn't a requirement. I think maybe that is something that, because I found that actually really helpful. I did like a sound walk with the children and got observed teaching it but actually the feedback from that was really helpful and insightful for me because it was kind of like a lesson that wasn't taught in the classroom as well.

1:08:19 So, we were walking around the school and listening to hear what we could hear, kind of thing, so that was quite good in terms of outdoor learning in boosting my confidence. And having a teacher who has been in the profession a long time being able to say, well you should have probably done, like you should have probably not stopped in the library during someone's guided reading with like a whole class of children. So, its things that you don't necessarily think about that actually then you are more confident next time because you think, awe, I won't do that again, kind of thing.

1:08:52 Interviewer: I think that's interesting though because as you go through the course, there is an assessment in year 2 but the assessment in year 3 is optional. So actually if we got everyone to be observed in one of their placements in science then it's another kind of science assessment, isn't it, that we could introduce.

1:09:15 Yes and maybe even encouraging, like, the assessment to be when you are doing an enquiry or an investigation or something that's a bit different from like you standing at the front of the classroom and… doing input and then setting the children off on a task. Because I do think that sometimes that's why people are a bit, people do that in observations because they know that not as much can go wrong, kind of thing. But actually its really valuable when you do do something a bit more risky because then the feedback that you get is, I always thought a bit more authentic, because it's like, 'oh you could have done this or you could have done that' and then it's like actually yes I'll do that next time.

1:10:00 Interviewer: thank you very much, I'll press stop on record.

Appendix 17: Summary of links between the evidence and the matrix

There were strong examples of children's learning that were emphasised in the interviews by the trainees as being important in terms of exceeding expectations in Table 1, similar to those in the research of Earle (2018), STA (2018b) and Osborne *et al*. (1992). The evidence shows the potential for children of this age to achieve the higher order thinking criteria. It has been directly linked to the matrix and shows the interpretations of the scientific learning in an outdoor context.

Source of evidence and link to the matrix	**Evidence sample**	**Interpretation**
TR1 interview (Appendix 16a)		
27:19 *(time within interview)* Questions-Analysis *(coding from the matrix)*	'So whilst they were doing their mini beasts, using the pooters, going outside, they were raising questions of where they found them, what they found them underneath. Then building that bug hotel, they were using the question stems… to help… they then raised questions… like 'Why did the worms actually live under soil?' 'what nutrients do they get from that?' So they were thinking deeper from what they had found and observed in the outdoors.'	Identify further questions arising from their results.
Appendix 18i Evidence-Comprehension	"I found this feather from the ground, what bird do you think it is?" "I think it is a small bird as the feather is very small, maybe a pigeon?" "No, pigeons are quite big! Let's search for some birds and see."	This shows that the development of their curiosity helped to engage them in discussing their findings and deciding to find out more.

TR2 interview (Appendix 16b)		
42:49 Ideas-Application	‘I think as far as we got with plants was that they have petals… whereas now they would be able to say about fungi, they would be able to list different types of plants, they would be able to explain how plants grow, the life cycle, so they've got a lot more information. So even saying leaves and roots, and they could explain how they absorbed water and nutrients and how they get their food, which they could never have done at the start. It wasn't as if I just spent the whole lesson just feeding them information either.’	This shows their ability to experience, recognise and name things in the natural world. Their understanding progressed from being able ‘to name’ to the children being able ‘to explain ideas, processes and phenomena’ such as describing the function of the petal within the reproduction of the plant.
50:10 Questions-Application *(The matrix does not take into consideration question types)*	‘Like I said with the vocabulary, so going from saying ‘what is a plant?’, ‘how do trees grow?’, ‘what is this on the floor?’, ‘why is that there?’ …..to them saying ‘why can you see the water particles on the grass?’. If they had asked that in the first session or two they would have just said ‘why is the floor wet?’. To be honest even saying ‘grass’ is quite a difference. Yes so going from just saying ‘what is this?’ to… ‘why do fungi grow on trees?’, ‘why not here?’ so ‘how does the water get back into the clouds after it has evaporated?’, ‘why do plants get food [misconception acknowledged] from the roots and why not from the sun?’	Developing vocabulary and changing the quality of the vocabulary in the question. Also progressing from just requiring a ‘yes’ or ‘no’ or one word answer to 2 part questions where it needed more of an explanation. They were trying to make connections and using cause and affect questions.
37:31 Problems-Application	‘One of the children was out of breath and I don’t think they would have acknowledged that as being science either, so I asked how it related to science and initially they sort of said ‘oh running and exercise’ so they were thinking about healthy lifestyle, and then when I prompted them to think about ‘why is she out of breath?’, they were able to say ‘oh she's run too fast’, ‘her hearts pumping fast’, ‘she's out of	Gives explanations using scientific vocabulary.

	oxygen'. So they could make those links.'	
37:31 Problems-Analysis	'They were….talking about the puddle, so I said what would happen to the puddle if the weather became minus 1 degrees, so I just thought I'd see if they could answer that and they were able to say that it would freeze, and it would turn into ice, because the particles change state; which was quite impressive.'	Used science experiences to explore ideas and raise different kinds of questions.
38:30 Problems-Synthesis	'Then they said what would happen if it was really hot and they were able to link that to like heat exhaustion, sunburn, hot countries, drought. They said because this was when it was happening in Australia, they said it would be like in Australia where they had bushfires and the plants and animals die because it's too hot and they don't get enough water, a spell of no rain is drought. So just making a lot of links with what they already know.'	Use what they already know to help them explain new things.

TR3 interview (Appendix 16c)		
39:25 Questions-Synthesis	'I wanted to say about the children using synthesis to make predictions based on their knowledge and understanding. So again I said about the bulbs growing in spring and them predicting that seeds can be carried by animals and wind like dandelions but bulbs can't - so again they were, kind of, again, using their prior knowledge.'	The learners demonstrated that they could make science predictions and as a result 'use what I already know to help me explain new things'.
44:11 Questions-Synthesis	'For example what I said about the bulb and 'could we put it in the freezer'… I said that they end their dormancy after the first frost and that child said 'oh, well we have already had the first frost so maybe they are not going to grow but we could do this…'	They demonstrated their pre-existing knowledge and experience. This enabled misconceptions to be addressed.

26:06 Questions-Analysis Also Ideas-Application	'One of the children said that the banana peel would decompose and compared that to mouldy bread that they have seen in their bread bin at home…. So they were talking about what they had seen …they said it was furry and blue, they were predicting that that's what would happen to the banana and again they said that it would go fluffy and mouldy after 3 hours.'	They demonstrated their pre-existing knowledge and experience. They identified changes related to scientific processes such as decomposition. (see 11.1.1)

This shows the examples of learning, links to the matrix and includes interpretations of this learning. The terms 'questioning-synthesis' represent the labels from the matrix in Figure 7.

In response to the subsidiary question 'in what ways can children be encouraged to think scientifically through utilisation of outdoor learning?' the examples of successful science in the outdoors provided an exemplification of the learning. They demonstrate 'how' the children were meeting the criteria and the high standards that they were achieving. These were based on a sample taken from the evidence gathered and emphasised the authenticity of the approach (Cohen *et al*. 2011). In contrast, procedural skills such as fair testing and the use of secondary sources were not exemplified here and suggest they do not easily relate to outdoor science learning.

Appendix 18: Trainee notes and reflections:

Appendix 18a: TR1 - Behaving like scientists

Child A suggested, "Science, I like learning where you can investigate, means finding things out in different ways."
Child B then adds, "Science, you feel like a detective, say if you want to investigate you have to take risks."

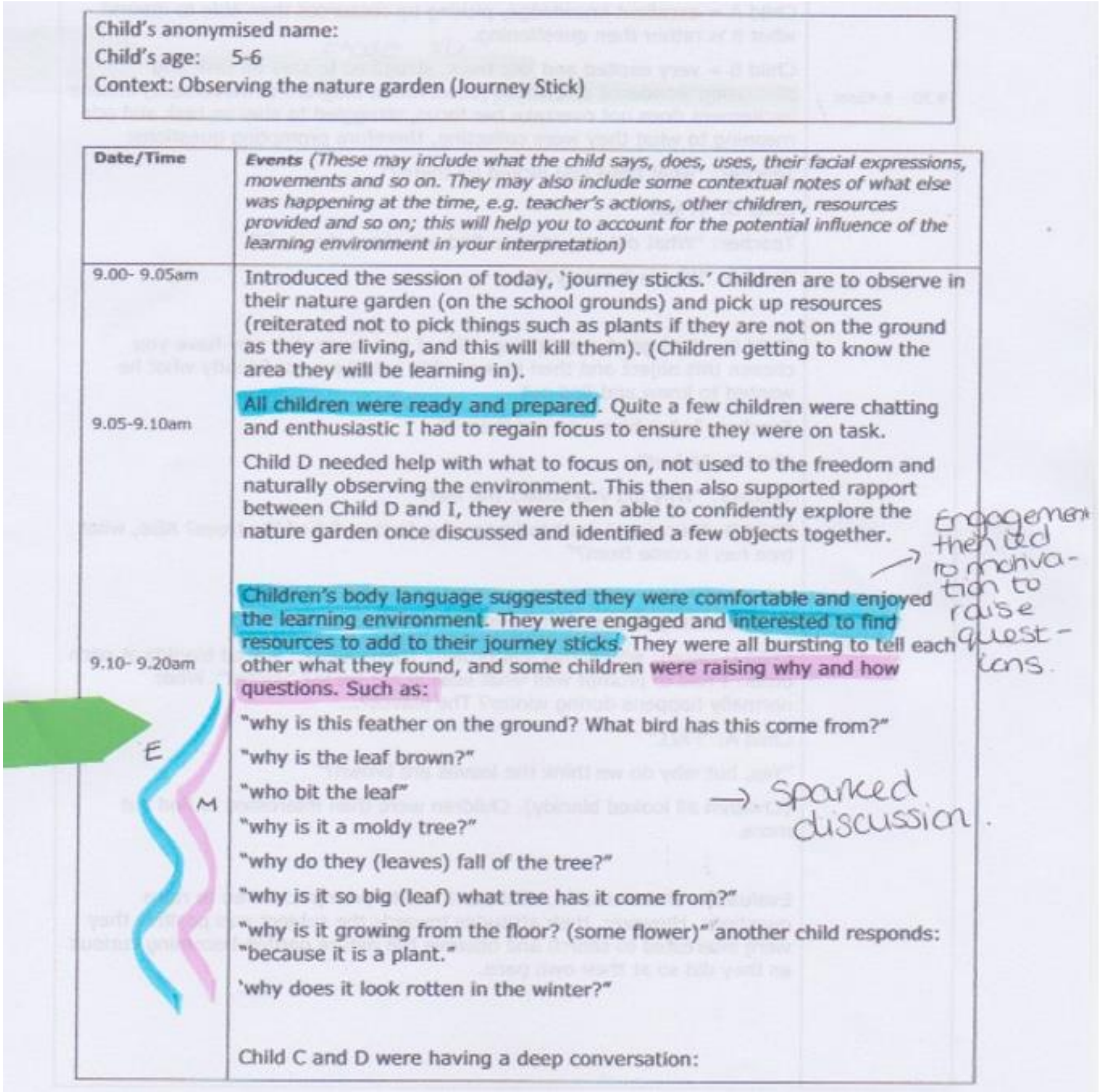
Children enjoy hands-on activities where they can investigate and take ownership of the learning.

Appendix 18b: TR2 - Authentic opportunities and affective attitudes

Utilising science enquiry skills and finding 'real-life' science, children build positive attitudes towards science education as they understand its purpose and importance. One pupil cautiously moved leaves because there 'might be bugs' and they 'did not want to kill them' indicating that they also have a greater appreciation for environments and the world.

Appendix 18c: TR1 - Freedom supported engagement

The freedom of the task allowed children the confidence to explore the nature garden and this then supported their engagement in the learning.
Children's body language suggested they were comfortable and enjoyed the learning environment. They were interested in finding resources to add to their journey stick.
Children are expressing engagement. The children raised questions during the task: "why is this feather on the ground? What bird has this come from?"
Their engagement in the freedom to explore interested children and motivated them to raise questions to support their knowledge, this could imply they were engaged.



Child's anonymised name:
Child's age: 5-6
Context: Observing the nature garden (Journey Stick)

Date/Time	**Events** *(These may include what the child says, does, uses, their facial expressions, movements and so on. They may also include some contextual notes of what else was happening at the time, e.g. teacher's actions, other children, resources provided and so on; this will help you to account for the potential influence of the learning environment in your interpretation)*
9.00- 9.05am	Introduced the session of today, 'journey sticks.' Children are to observe in their nature garden (on the school grounds) and pick up resources (reiterated not to pick things such as plants if they are not on the ground as they are living, and this will kill them). (Children getting to know the area they will be learning in).
9.05-9.10am	All children were ready and prepared. Quite a few children were chatting and enthusiastic I had to regain focus to ensure they were on task. Child D needed help with what to focus on, not used to the freedom and naturally observing the environment. This then also supported rapport between Child D and I, they were then able to confidently explore the nature garden once discussed and identified a few objects together.
9.10- 9.20am	Children's body language suggested they were comfortable and enjoyed the learning environment. They were engaged and interested to find resources to add to their journey sticks. They were all bursting to tell each other what they found, and some children were raising why and how questions. Such as: "why is this feather on the ground? What bird has this come from?" "why is the leaf brown?" "who bit the leaf" "why is it a moldy tree?" "why do they (leaves) fall of the tree?" "why is it so big (leaf) what tree has it come from?" "why is it growing from the floor? (some flower)" another child responds: "because it is a plant." 'why does it look rotten in the winter?" Child C and D were having a deep conversation:

Engagement then led to motiva-tion to raise quest-ions.

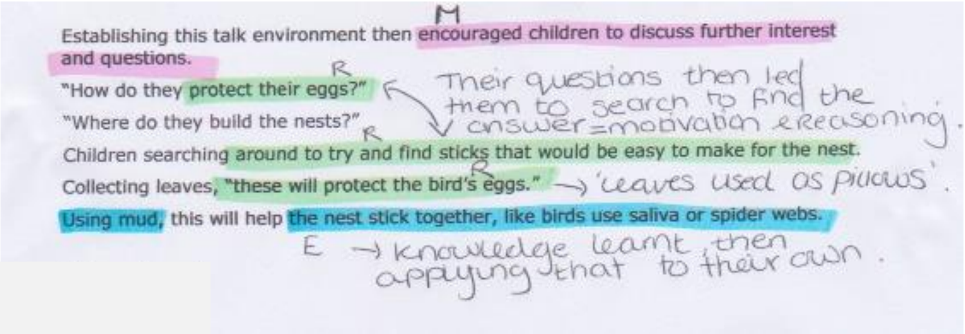
E

M

→ Sparked discussion.

Planning experiments gives children that ownership, they become invested about the task in hand.

Children could become motivated and interested towards the learning when they have an active part, suggesting children may develop determination and resilience towards science.



M

Establishing this talk environment then encouraged children to discuss further interest and questions.

R

"How do they protect their eggs?"

"Where do they build the nests?" R

Their questions then led them to search to find the answer = motivation & reasoning.

Children searching around to try and find sticks that would be easy to make for the nest.

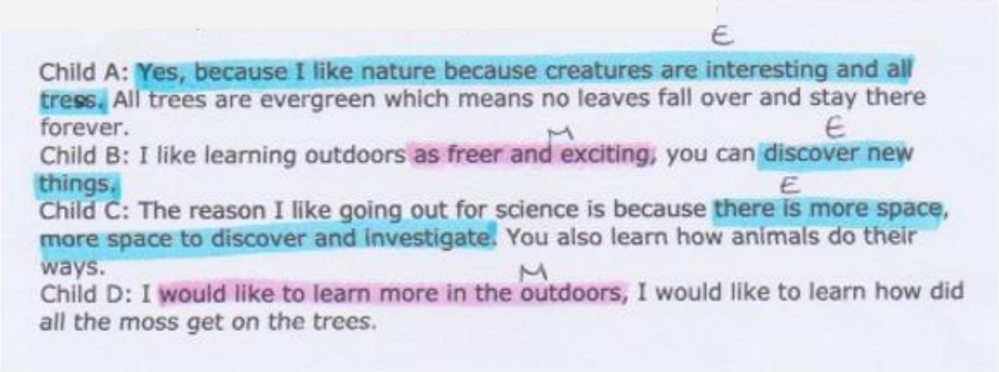
R

Collecting leaves, "these will protect the bird's eggs." → 'leaves used as pillows'.

Using mud, this will help the nest stick together, like birds use saliva or spider webs.

E → knowledge learnt, then applying that to their own.

The children showed a strong passion towards learning in the outdoors which suggests that their engagement towards the learning would be evident.



E

Child A: Yes, because I like nature because creatures are interesting and all tress. All trees are evergreen which means no leaves fall over and stay there forever.

M E

Child B: I like learning outdoors as freer and exciting, you can discover new things.

E

Child C: The reason I like going out for science is because there is more space, more space to discover and investigate. You also learn how animals do their ways.

M

Child D: I would like to learn more in the outdoors, I would like to learn how did all the moss get on the trees.

Appendix 18d: TR2 - Thinking like scientists

T: What did we do that scientists do?

'Collect data, collect evidence, explored, collected ideas'

T: Why might scientists need to see their resources?

'Plan' 'Ideas and Planning' 'See tools and equipment'

T: *What skills might you use?*

'Questioning' 'Teamwork' 'Reasoning' 'Thinking'

Appendix 18e: TR1 - Curiosity and motivation

The importance of planning innovative strategies to ensure children develop ownership in their learning to spark curiosity.

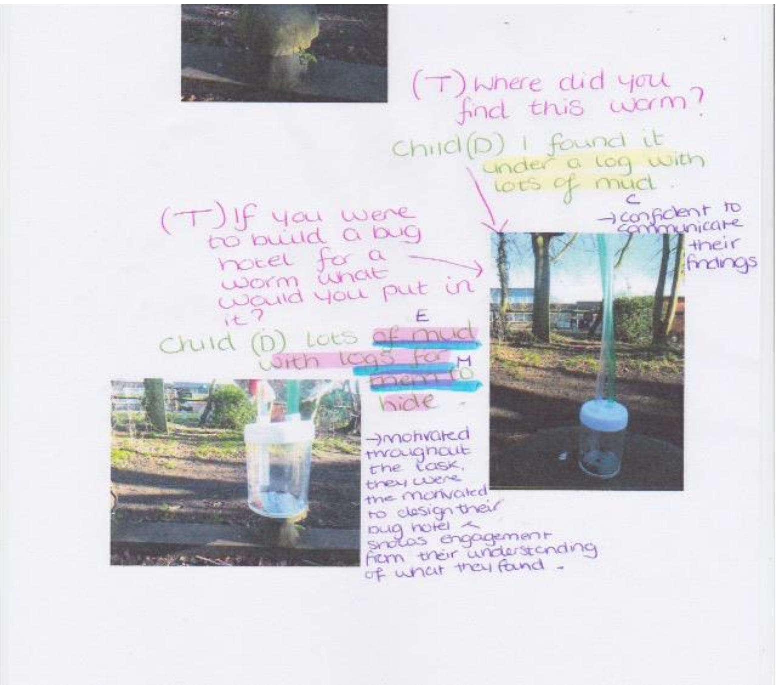
Planning experiments gives children that ownership, they become invested about the task in hand.

Children could become motivated and interested towards the learning when they have an active part, suggesting children may develop determination and resilience towards science.

Appendix 18f: TR1 - Curiosity and the outdoors

Children are curious about what they have found and motivated to discover.

Designing an environment that influences children's curiosity will further enhance their motivation in which can lead to them learning at their own pace.



(T) Where did you find this worm?

Child (D) I found it under a log with lots of mud.

C

→ confident to communicate their findings

(T) If you were to build a bug hotel for a worm what would you put in it?

E

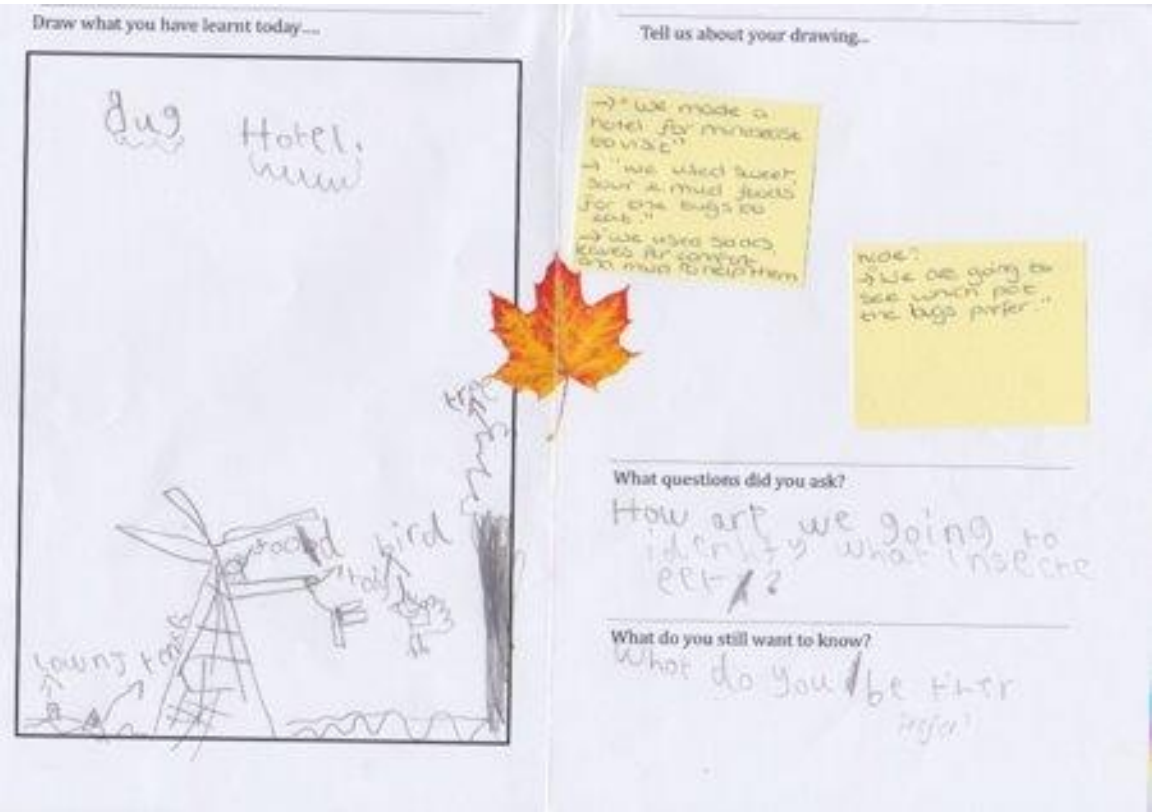
Child (D) lots of mud with logs for them to hide.

M

→ motivated throughout the task, they were the motivated to design their bug hotel < shows engagement from their understanding of what they found.

Appendix 18g: TR3 - Curiosity and questioning

A child-led approach when teaching scientific enquiry can encourage children to ask questions and make predictions based on their curiosity



Draw what you have learnt today....

Tell us about your drawing...

→"We made a hotel for minibeasts to visit"
→"We used sweet sour & mud foods for the bugs to eat."
→"We used sticks leaves for comfort and mud to help them

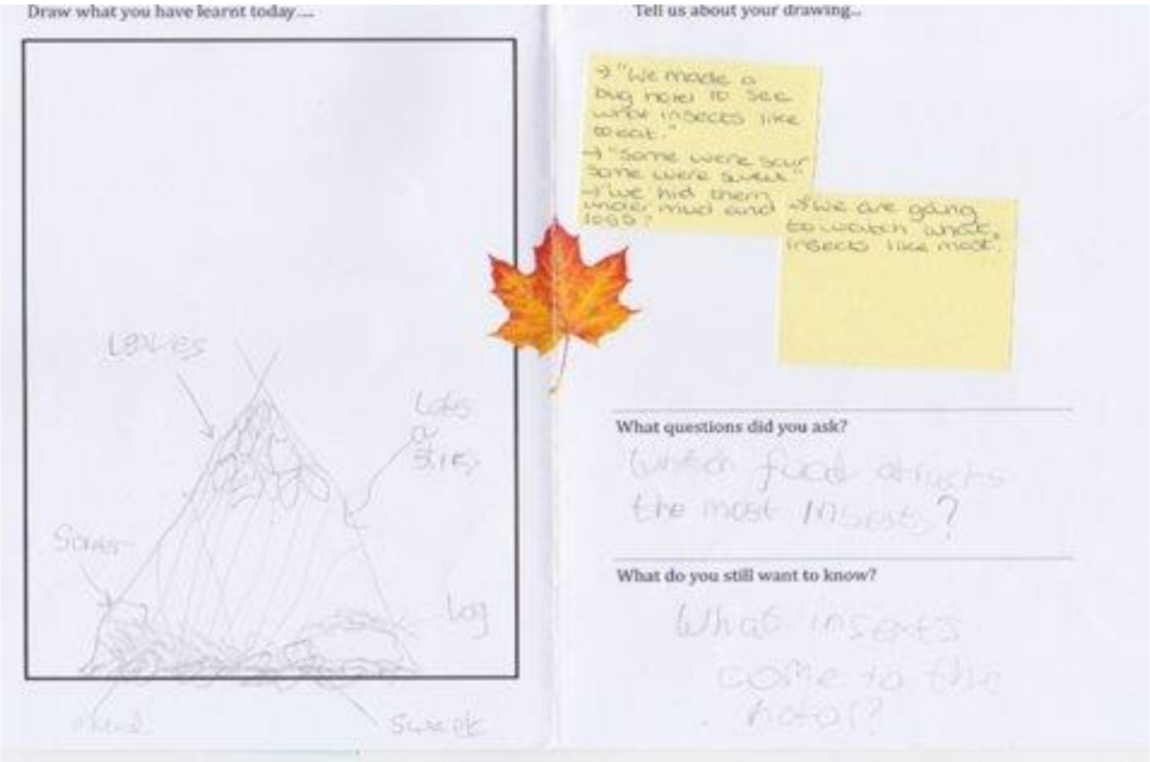
Now?
→"We are going to see which pot the bugs prefer."

What questions did you ask?

How art we going to idrnity what insecthe eet?

What do you still want to know?

What do you be ther prfer?



Draw what you have learnt today....

Tell us about your drawing...

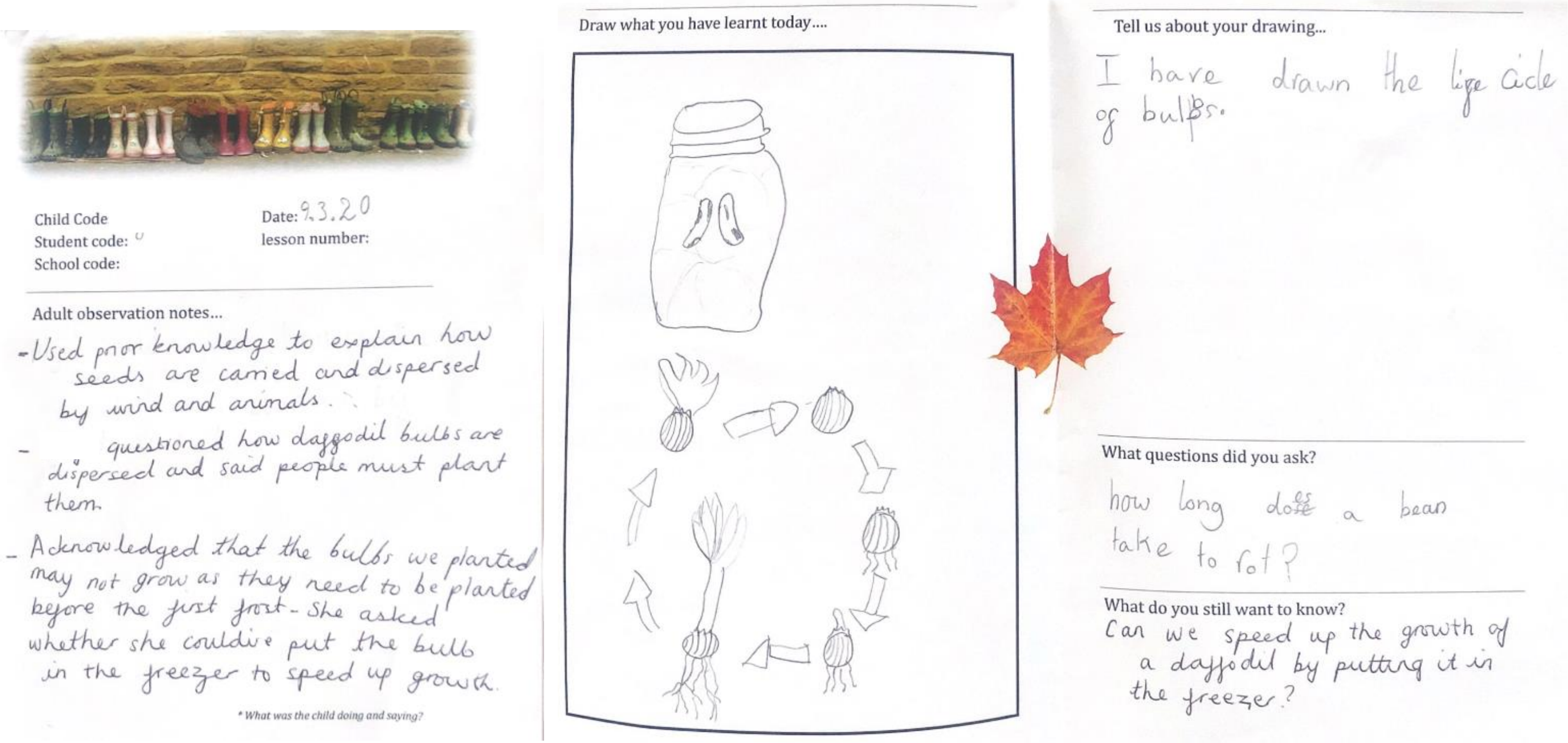
→"We made a bug hotel to see what insects like to eat."
→"Some were sour some were sweet."
→"We hid them under mud and logs."
→"We are going to watch what insects like most."

What questions did you ask?

Which food atracts the most insects?

What do you still want to know?

What insects come to the hotel?



Child Code
Student code:
School code:

Date: 9.3.20
lesson number:

Adult observation notes...

- Used prior knowledge to explain how seeds are carried and dispersed by wind and animals.
- questioned how daffodil bulbs are dispersed and said people must plant them.
- Acknowledged that the bulbs we planted may not grow as they need to be planted before the first frost - She asked whether she couldive put the bulb in the freezer to speed up growth.

* What was the child doing and saying?

Draw what you have learnt today....

Tell us about your drawing...

I have drawn the life cicle of bulbs.

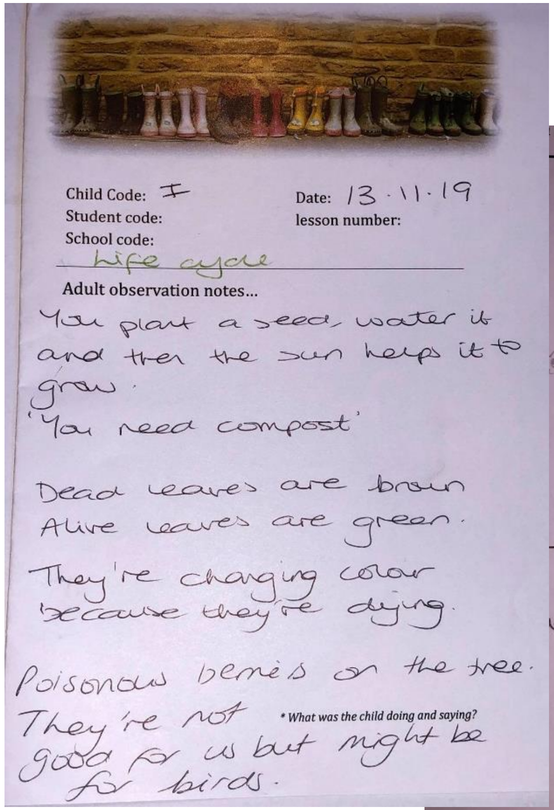
What questions did you ask?

how long does a bean take to rot?

What do you still want to know?

Can we speed up the growth of a daffodil by putting it in the freezer?

Appendix 18h: TR3 - Questions arising from curiosity



Child Code: I

Student code:

School code:

Date: 13.11.19

lesson number:

Life cycle

Adult observation notes...

You plant a seed, water it and then the sun helps it to grow.

'You need compost'

Dead leaves are brown

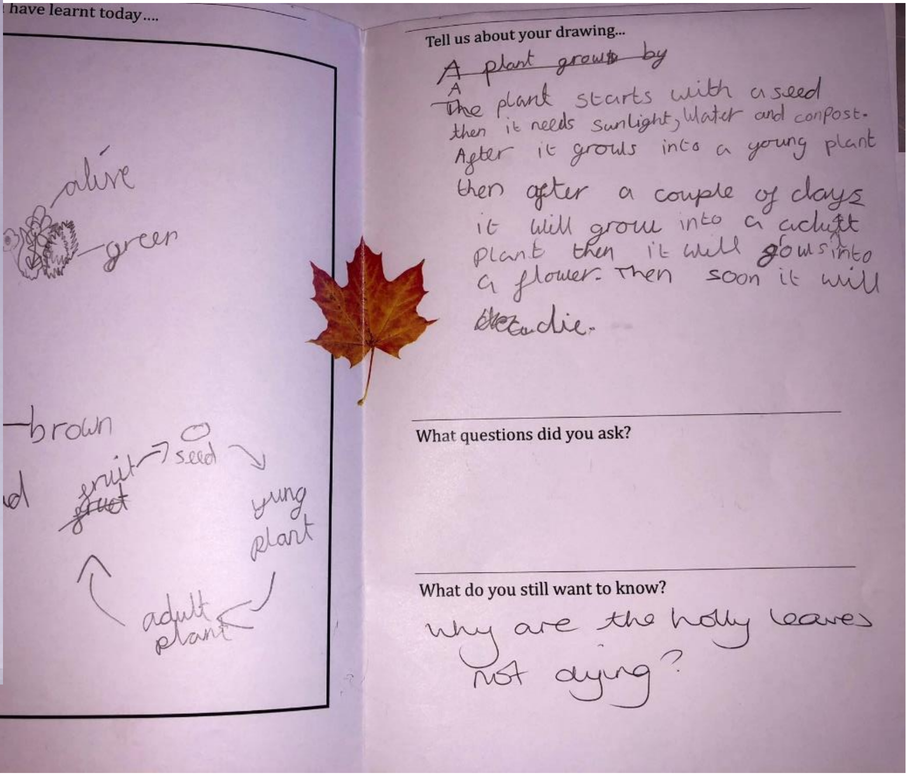
Alive leaves are green.

They're changing colour because they're dying.

Poisonous berries on the tree.

They're not good for us but might be for birds.

* What was the child doing and saying?



have learnt today....

Tell us about your drawing...

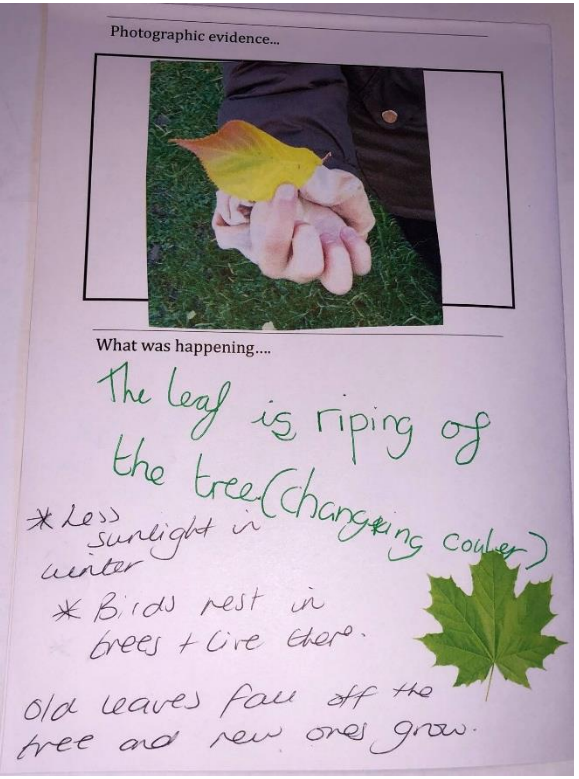
~~A plant grows by~~

A plant starts with a seed then it needs sunlight, water and conpost. After it grows into a young plant then after a couple of days it will grow into a adult plant then it will grows into a flower. Then soon it will ~~die~~ die.

What questions did you ask?

What do you still want to know?

why are the holly leaves not dying?



Photographic evidence...

What was happening....

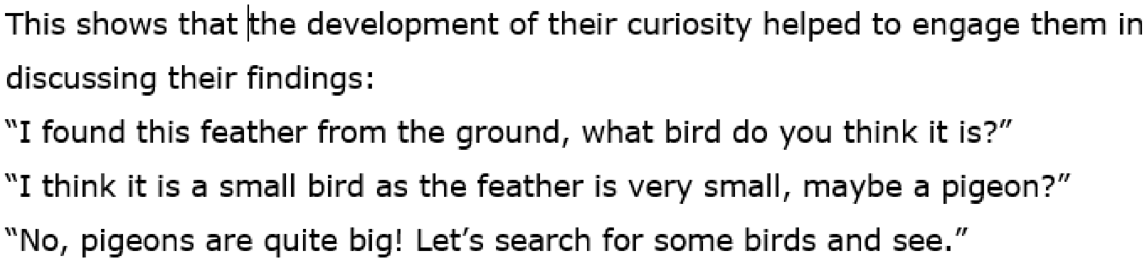
The leaf is riping of the tree (changing couler)

* Less sunlight in winter

* Birds nest in trees + live there.

Old leaves fall off the tree and new ones grow.

Appendix 18i: TR2 - Raising questions with the freedom and time to explore



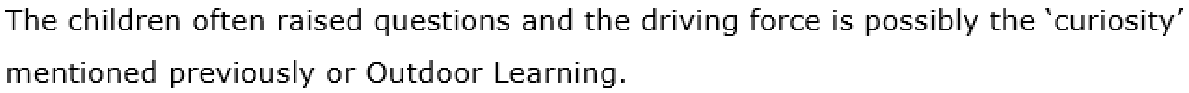
This shows that the development of their curiosity helped to engage them in discussing their findings:

"I found this feather from the ground, what bird do you think it is?"

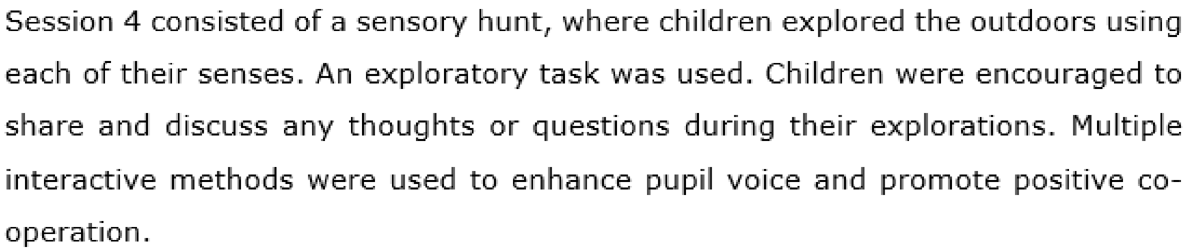
"I think it is a small bird as the feather is very small, maybe a pigeon?"

"No, pigeons are quite big! Let's search for some birds and see."

Appendix 18j: TR2 - Question generation



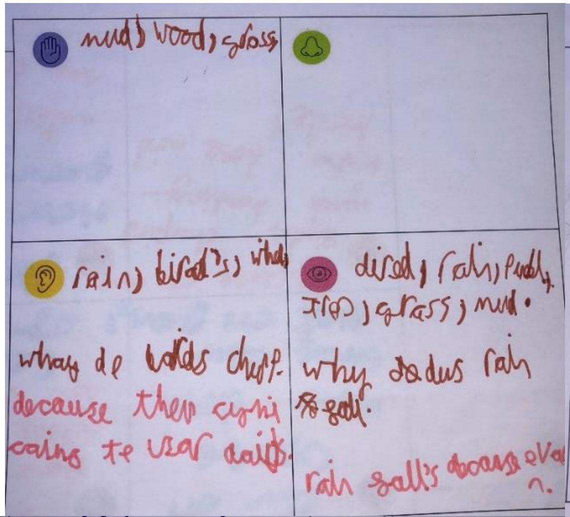
The children often raised questions and the driving force is possibly the 'curiosity' mentioned previously or Outdoor Learning.



Session 4 consisted of a sensory hunt, where children explored the outdoors using each of their senses. An exploratory task was used. Children were encouraged to share and discuss any thoughts or questions during their explorations. Multiple interactive methods were used to enhance pupil voice and promote positive co-operation.

The increased pupil questioning during session 4 could be explained by heightened opportunity outdoors to explore and prompt to ask questions

Appendix 18k:TR2 - Questions from close observations



mud, wood, grass

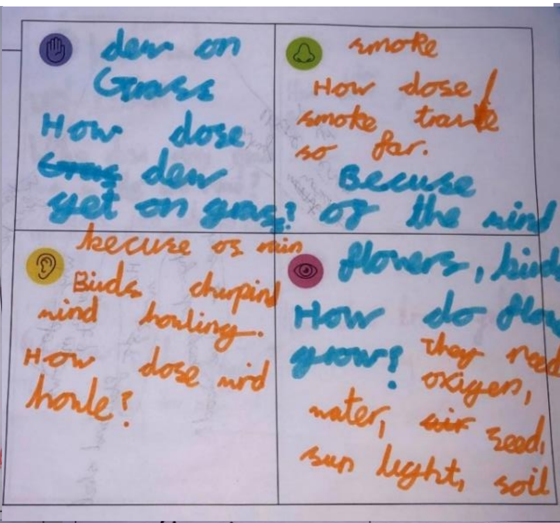
rain, bird's, what

what de birds churp.
decause they cyhi
caing te usar daits.

dird, rain, Puddl,
tree, grass, mud.

why dodus rain
fall.

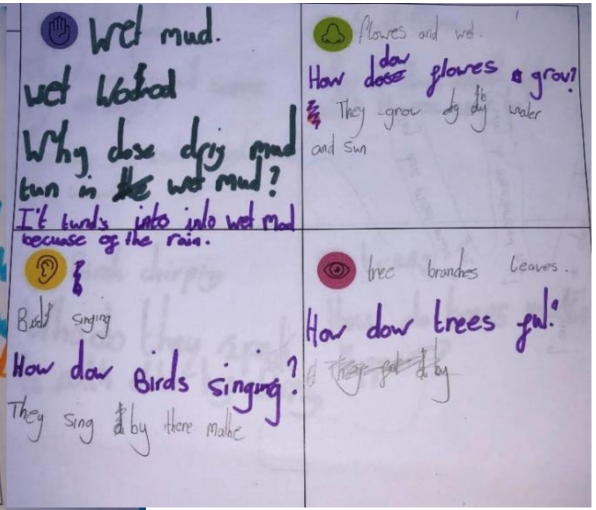
rain fall's docause evan.



dew on
Grass
How dose ~~Grass~~ dew
get on grass?

smoke
How dose smoke taste
so far.
Becuse of the wind
becuse of rain

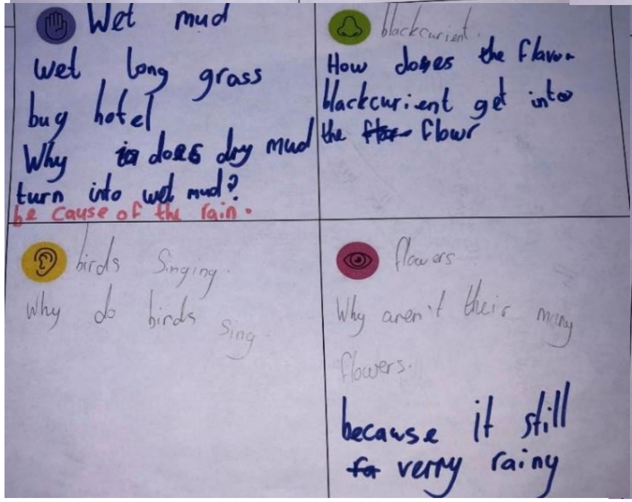
Birds chirpin
wind howling.
How dose wind
howle?

flowers, birds
How do flowers
grow? they need oxigen,
water, ~~air~~ seed,
sun light, soil

Wet mud.
wet wood
Why dose dry mud
turn in ~~the~~ wet mud?
It turns into into wet mud
because of the rain.

Flowes and wet.
How ~~dose~~ dow flowes grow?
They grow by water
and sun

Birds singing
How dow Birds singing?
They sing by there mathe

tree branches leaves.
How dow trees gol:
~~they get by~~

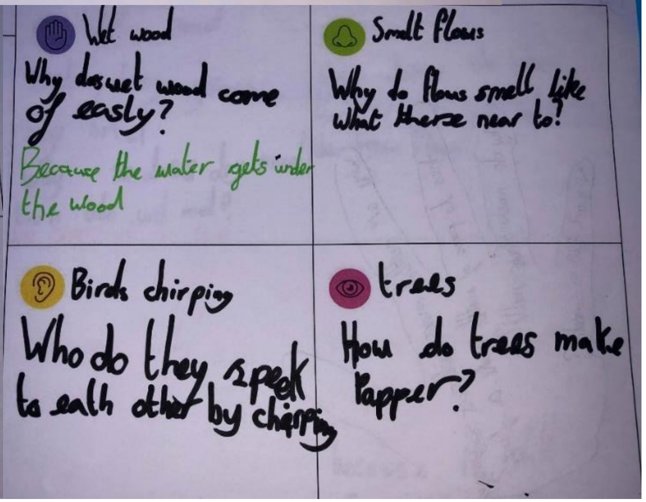


Wet mud
wet long grass
bug hotel
Why does dry mud
turn into wet mud?
be cause of the rain.

blackcurient
How doses the flavor
blackcurient get into
the ~~flav~~ flowr

birds Singing
why do birds Sing

flowers
Why aren't their many
flowers.
because it still
~~fo~~ very rainy



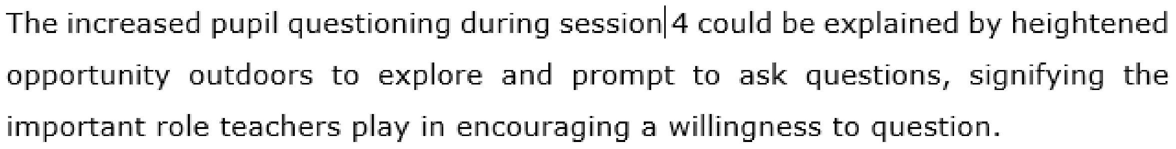
Wet wood
Why dos wet wood come
of easly?
Because the water gets under
the wood

Smell flows
Why do flows smell like
what there near to?

Birds chirping
Who do they speak
to each other by chirping

trees
How do trees make
Papper?

Appendix 18I: TR2 - Outdoor context stimulated questions



The increased pupil questioning during session 4 could be explained by heightened opportunity outdoors to explore and prompt to ask questions, signifying the important role teachers play in encouraging a willingness to question.

'Would you prefer to do science indoors or outdoors? Why?'

All: Outdoors

'More to do' (2) 'Find real plants and minibeasts' (2) 'Act differently'

'More fun' (3) 'Ask more questions' (3) 'Activities and investigation'

'Explore' (3) 'More freedom' 'Space' 'Nature and things alive'

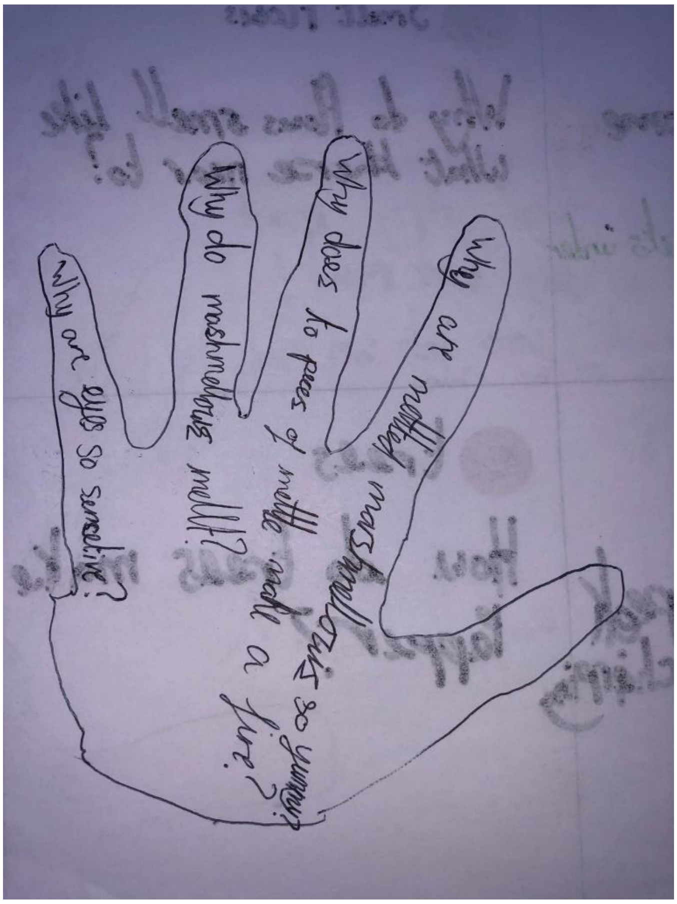
'Find real things' (4) 'Bigger' (2) 'Talk more' (2) 'Fresh air'

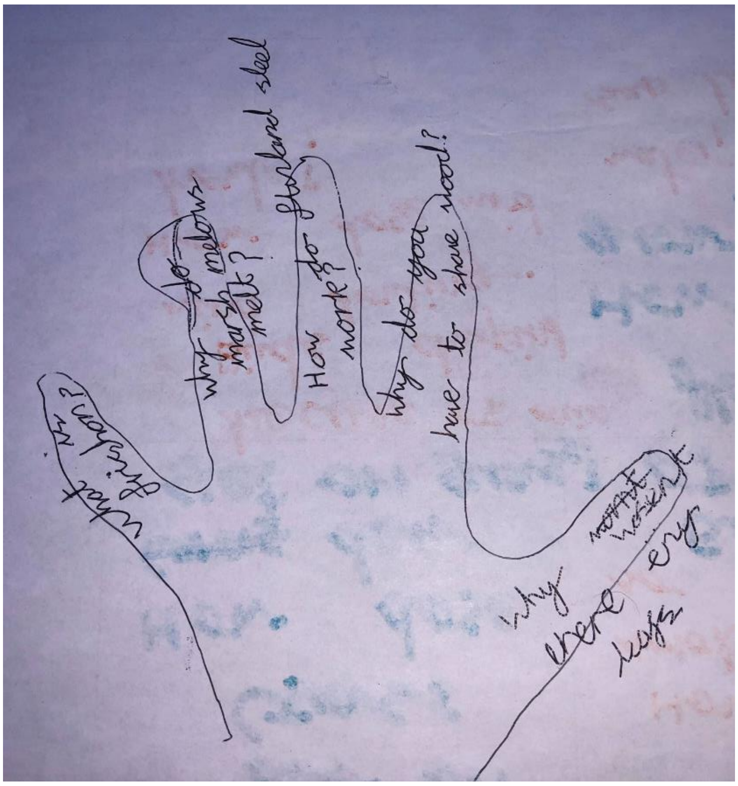
'More movement' (2) 'Easier to talk to the teacher 'Real world'

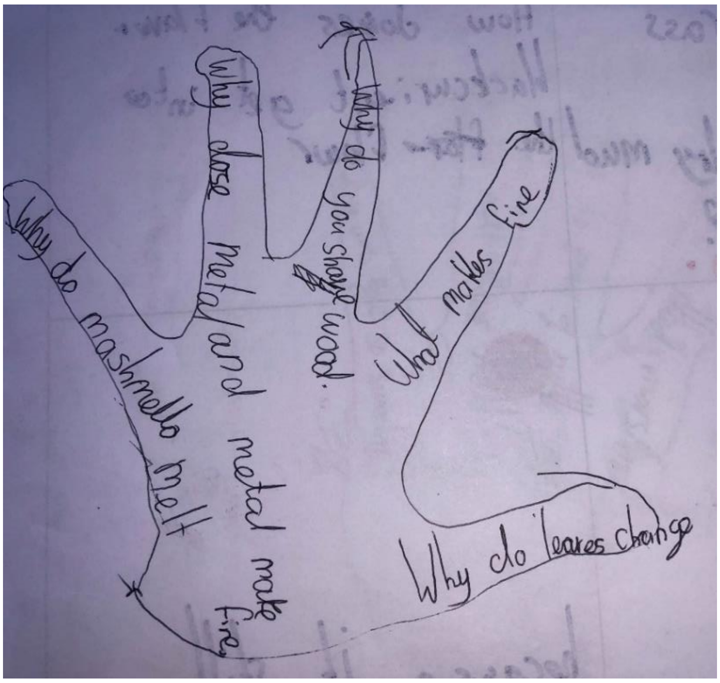
'Touch things' 'Look at things' 'independent' 'Connect with the outdoor world'

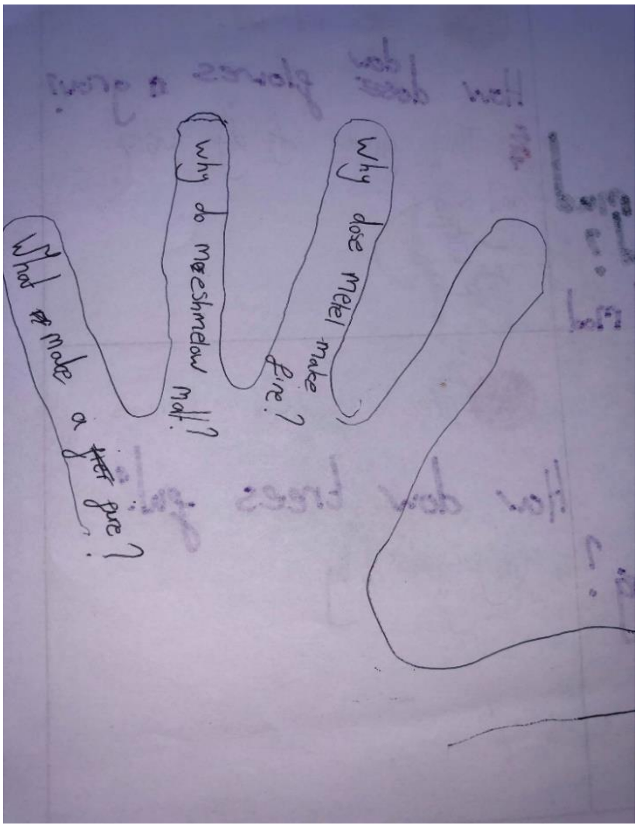
'Different to the classroom – Not just writing'

Appendix 18m: TR1 - Question hands









Appendix 19: The limitations, mitigation and suitability associated with the methods

Method	Limitations	How these were mitigated	How the method helped to answer the research questions.
Documentary analysis	Documentary analysis was time-consuming to deploy and required methodical analysis.	The authenticity, credibility, representativeness and meaning of the raw data was critiqued within the analysis to increase the accuracy and provide a more trustworthy view of the learning.	The benefit was that the child's view was represented through the data collection in the booklets and wider field notes. These documents provided an insight into the learning and a more balanced representation of the learning that was involved as a whole.
	The evidence was susceptible to a degree of subjectivity.	A range of perspectives provided multiple realities because understanding was influenced by contextual factors. Triangulation was used to provide multiple interpretations of the documents that were being analysed.	A subjective approach provided accessibility, authenticity and the opportunity to demonstrate agency.
Observations	The consistency in the recording of observations. There were challenges associated with taking photographs which was due to the availability of digital	I worked with the trainee teachers to develop the booklets as a fit-for-purpose way of recording to provide consistency. I acknowledged that observing and recording at the same time was limiting especially when working with young children who were	Consistent recoding supported the analysis of the learning including noticing commonalties or mismatches in the evidence

	devices, cameras and trainee confidence.	moving and spread out. Devices were made available from the university resources and a flexible approach was taken to enable the trainees to maximise the recording of observations.	
	Perception and reality could have been influenced by the trainees' insider knowledge of the children, their opinions and personal bias. There was potential subjectivity involved in the non-interpretivist observations.	I supported the trainee teachers in identifying their own bias within their observations. They completed peer reviews of their observations with a focus on subjectivity and bias. I attempted to distinguish between justified belief and opinion through encouraging the trainees to demonstrate their points with examples of the learning.	Enabling trainees to acknowledge their own biases provided greater insight into the learning and more reliable findings. Looking and listening within observations involved doing so radically, critically and openly.
Interviews	Limitations were considered as a result of the participants being hesitant to articulate their experiences. Non-verbal and verbal techniques were used during the interviews, however, these were more challenging to manage online with issues of eye contact and limited interaction.	I took time to put them at ease before the interview and reassured them that they would not be judged as a result of their comments. Interactions were made easier because a relationship with the trainee teachers had already been established over their four-year degree. There needed to be a balance between active listening and enabling the participants to talk and this was done by ensuring they were not cut off before they had finished making their points, whilst showing I was engaged in the discussion.	The interviews involved sense checking and offered the trainees' interpretation of the evidence. All trainee teachers felt able to explain their findings and their enthusiasm was evident in their responses, thereby providing a clear insight into the learning.

	The potential for misunderstandings due to pauses and inferred meaning in the moment.	Misunderstandings were counteracted by revisiting the discussions through the use of the transcripts. I made these available for the trainees to check for accuracy and omissions.	The transcripts provided an accurate representation of the interviews.
	There was the possibility of a power imbalance and issues of bias influencing the trainees' responses.	To minimise the power imbalance and prevent bias, the interviews were conducted after the trainees had completed their course and received their qualification.	The trainees were in a position to look back and reflect upon the experience as insiders.
	Recording learning conversations in the moment were more challenging for trainees to document than those that were reflective post-learning.	This was mitigated by the use of electronic devices and establishing routines which had been developed through the university training. Field notes were valued and booklets provided a structure for recording either outside or inside.	Benefits of capturing conversations about the learning 'in the moment' included natural, honest and open responses, ensuring evidence of learning was not forgotten.