An examination of global learning as an approach to develop the purpose and value of science in primary schools in England

Thesis submitted in accordance with the requirements of Liverpool Hope University for the degree of Education Doctorate

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The Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's *Regulations and Code of Practice for Research Degree Programmes* and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Any views expressed in the dissertation are those of the author.

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Abstract

Global learning is a pedagogical approach which puts global citizens at the heart of learning. As an emerging area of study with an evolving terminology, it is rarely considered in the delivery of discrete subject disciplines. Through the overarching research question '**To what extent, and in what ways, does a global learning approach develop the purpose and value of science in primary schools?**', this thesis considers how primary science education can be underpinned by a global learning approach through exploring practitioner attitudes and teachers as agents of change. In the context of global learning in primary science professional development, underpinned by a planning framework, the study investigated strategies that influence teachers' beliefs and agency and subsequent approach to primary science.

After a review of the developments and challenges of primary science education, the literature review focuses on models of science-specific professional development, professional beliefs and teachers as agents of change, concluding how these constructs have informed a global learning approach. The study's methodology is positioned within a social constructive / pragmatic paradigm. The thesis uses an embedded mixed-methods approach with 150 attitudinal surveys and 25 semi-structured interviews of key primary science stakeholders (Senior Leadership Team, Advisors of primary science, heads of science, teachers, and student teachers), together with three case study schools who trialled the global learning approach to primary science over a year-long period. Data (including teacher interviews, planning and work samples) were used to inform an amended framework supporting a global learning approach to primary science education.

The findings of this research revealed that whilst teachers' attitudes towards global learning were positive, their sense of agency appeared to influence their approach to primary science. For example, when practitioners were able to identify links between the approach and policy framework, they were more likely to consider its integration. Furthermore, when practitioner beliefs about primary science aligned with the aims of a global learning approach, the practitioners were more likely to engage with the professional development. In relation to professional development strategies, school culture (such as opportunities for collaborative planning and distributed leadership), together with a global learning framework (planning tools, modelled strategies, resource banks and links to Sustainable Development Goals), were important factors supporting teachers as agents of change. Developing practitioner Pedagogical Content Knowledge in both global learning and primary science appeared imperative to the sustainability of the approach.

The findings of this study led to the development of a revised framework for professional development in global learning in primary science education and greater opportunities for related professional discourse, supporting teachers as agents of change, informing a primary science education fit for future global citizens.

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Abbreviations

ASE	Association of Science Education
COP	Community of Practice
CPD	Continued Professional Development
DfE	Department for Education
ESD	Education for Sustainable Development
GCE	Global Citizenship Education
GLP	Global Learning Programme
GTP	Graduate Teacher Programme
ITE	Initial Teacher Education
NFER	National Foundation of Educational Research
OECD	The Organisation for Economic Co-operation and Development
OSDE	Open Spaces for Dialogue and Enquiry
P4C	Philosophy for children
PCK	Pedagogical Content Knowledge
PGCE	Post Graduate Certificate in Education
PISA	Programme of International Student Assessment
PSQM	Primary Science Quality Mark
PSTT	Primary Science Teachers Trust
SDG	Sustainable Development Goal
SLT	Senior Leadership Team
STEM	Science Technology Engineering and Mathematics
TAPS	Teacher Assessment in Primary Science
TIMSS	Trends in International Mathematics and Science Study

CHAPTER ONE OVERVIEW OF THE THESIS

1.1 Introduction to Chapter one

Global learning is a pedagogical approach that puts learning in a global context, fostering critical and creative thinking, self-awareness and open-mindedness towards difference, understanding of global issues and action and optimism for a better world (Bourn, 2016). At a primary level, global learning is strongly linked to the development of socially aware, responsible global citizens (Hunt, 2012). Delivering primary science education through a global learning approach provides an opportunity for global citizenship to be underpinned by scientific knowledge and thinking, enabling young people to make informed decisions and take responsible actions.

This introduction chapter will begin with an outline of the historical changes and current status of primary science education in England, considering why primary science is not used as a foundation through which to develop global citizens. It will then critically analyse the challenges of developing an education underpinned by global citizenship. Finally, it will consider the challenges related to the implementation of a science education suitable for our future global citizens, providing a rationale for exploring a global learning approach to primary science, underpinning the thesis aims, hypotheses and significance of the research.

1.2 The developments of primary science education in England

Dewey's ideas (1910, cited in Jenkins, 2014) had an important influence on the teaching of science, sharing a belief that science education was more than acquiring knowledge, but learning how to solve problems. Dewey considered that science education should be focused on inquiry, enabling children to learn how to think and solve problems independently (Jenkins, 2014). Articulated in Dewey's writing, (Dewey, 2010 cited in Rudolph, 2014) was the idea that the purpose of science education should be to ensure citizens are able to understand the role and use of scientific thinking as a tool in modern society; something that is reflected in the more recent research related to science capital (Archer, Dewitt and King, 2018). Whitehead's (1929) aims of education also drew parallels between how scientists worked, and how children learn, claiming that they are motivated by curiosity, utility and a grasp of the fundamental principles that govern the natural world (using problem-solving and enquiry skills). This thesis is underpinned by the belief that primary science education in England should enable and motivate children, as global citizens, to understand the role, uses and opportunities of science. How this is achieved needs to be considered.

After World War Two, there was a progression towards large-scale science as a result of industrial demands (Braund and Reiss, 2007). This brought greater calls for a wider public knowledge of science and a requirement for more scientists. The 1944 Education Act brought state funded education for all children, during which learning focused on the memorising of facts. It was not until the 1960s when

developments in the secondary science curriculum moved science teaching away from the memorising of discrete facts towards understanding and application of science. Regrettably, a lack of funding, lack of consensus of the aims and content, and a lack of research evidence of its benefit resulted in less attention being given to primary science in England (Tymms, Bolden and Merrell, 2008:8). Between 1944 and 1988, as a result of not being specifically stipulated to be taught, primary science continued to receive limited attention (Jenkins, 2014:14). During this time, different approaches were, however, explored for science education of younger children. Whilst criticised by a traditional view of science knowledge being learned in the same way by all students, Gagne's (1970) process learning theory influenced an inquiry approach to science, allowing students to acquire new knowledge through practice and application. As well as the developments of inquiry-based learning in science, Harlen's (1985) work also influenced the importance of fostering positive attitudes towards science at a primary level as an important foundation for science education. These developments supported the importance of inquiry learning: not just inquiry to learn scientific facts and skills, but inquiry to develop positive attitudes towards science, and to develop an understanding of the nature of science. Holman (2017) supports this by highlighting that the purposes of practical science (both inquiry-based learning and scientific inquiry) include teaching the principles of scientific inquiry, improving theory through practical experience, teaching skills, motivating and engaging students and developing higher level skills such as communication, teamwork and perseverance. I would encourage that the last of Holman's purposes involve developing global skills which as well as communication, teamwork and independence, may also include a respect for others' perspectives, a sense of interdependence and self-reflection and critical thinking.

The Education Reform Act of 1988 in England brought the introduction of the statutory curriculum in primary schools. A structured science curriculum was received by all primary children, supported by professional organisations and professional development. During the 1990s, as identified by White (2008), teachers began to question the purpose of the National Curriculum, which subsequently motivated the government to publish its aims and values. The National Curriculum Handbook (DfEE / QCS, 1999:10-11) outlined the aims of the National Curriculum which included the importance of developing successful learners, confident individuals and responsible citizens. In agreement with White (2008), if teachers' attention were constantly directed to these aims and values, then they may have been liberated to shape their teaching and learning activities with these aims and values in mind. However, along with other subjects, within the remainder of the curriculum handbook (DfEE/ QCA, 1999) the science curriculum focused heavily on laying the foundations of specialist knowledge required for learners to pursue science in their future education careers (White, 2008). As emphasised by Kelly (1983), curriculum has an impact on the way we see a subject, in this case, science. As a result of a focus on attainment descriptors, it was, as White (2008) argued, seen as a body of knowledge to be transmitted.

During the 1990s, the influence of science and technology development on all aspects of everyday life supported the core curriculum status of science, along with English and mathematics. A greater

public understanding of science, greater scientific literacy, science-related policies (such as health and technology) also supported the subject's status within the curriculum. Many primary school initiatives moved towards a constructivist model of learning (Naylor and Keogh, 1999), focusing on the provision of a range of active experiences and dialogic learning to elicit misconceptions and encourage conceptual change. Between the early 1990s and early 2010s, however, children had to take statutory assessments at the end of Key Stage 2 science. As a consequence, many teachers reverted to a didactic approach of knowledge transmission in order to fulfil requirements of these high-stake tests (ASE, 2008). The abolishment of these tests in 2009 aimed to alleviate pressures of curriculum coverage and test preparation and increase the enthusiasm for science teaching and learning, but instead resulted in the subject being devalued without being a focus of inspection or accountability (McCrory, 2017). Whilst I argue that returning to end-of-key-stage testing is not the solution, exploring ways to re-establish the core curriculum status of primary science is why this study is important.

A report from the National Audit Office (2018) reviewed the government's acknowledgement of and investment in science (under the umbrella of science, technology, engineering and maths, bringing these disciplines together) skills and whether education was meeting the demands of a rapidly changing and globalised economy. Unfortunately, the findings identified a lack of coordination between science-related initiatives and science education, predicting a negative impact on science development. A more recent report focusing on the impact of Covid-19 school closures to primary science education highlighted that once re-opened, schools, teachers and parents prioritised the coverage of English and mathematics, leaving even less time to the support of science learning, especially in more deprived areas of England (Canovan, 2020). At a time when an understanding and application of science knowledge and thinking is even more important, its (often) reduced status in primary education may exacerbate existing inequalities as to who can access and use science within their futures.

This supports the statement by Braund and Reiss (2007) who argue that the UK, along with many other developed countries, have a science education which is in a **state of crisis** [emphasis my own] and does not provide young people with the scientific understanding, reasoning and literacy required to engage with (and meet the demands of) science in the modern world. The 2018 PISA science results, as indicated by the NFER education briefings (2018) not only show that England is significantly outperformed in science by many of countries in Asia, but a lack of desire to become scientists and engineers has also been highlighted (boys in England are more likely to aspire to become a scientist/ engineer than girls:16 and 6 per cent respectively). This is supported by DeWitt and Archer (2015) whose research highlights the disparity between positive attitudes towards science and aspirations to pursue it as a career. Reiss and White (2014:1) go on to agree that science education continues to focus on curriculum coverage rather than the fundamental aims which, they argue, are to 'lead a life that is personally flourishing and to help others to do so'. Reiss and White (2014) argue that starting with the needs and wants of students beyond school learning will enable learning experiences to be much more consistent with the activities that scientists and technologists do in the real world of

science. A recent report by Shirazi (2017) supports this view, underlining the impact of this disparity on young people's pursuit of science in their further education.

The Report to the European Commission entitled 'Science Education for Responsible Citizenship' chaired by Hazelkorn (2015: 7) outlines the importance of developing educational processes which better equip future citizens with the 'knowledge, motivation and sense of societal responsibility' to participate actively and responsibly in science-informed decision making and knowledge-based innovation, which goes beyond current expectations of the current curriculum in England. I hold the view that this is the purpose of science education. Baram-Tsabari and Osborne (2015) go on to advocate the importance of a common vision of the role and importance of science between science education and science communication research (informed by the work of Thomas and Durant (1987) as the practice of informing, educating, sharing awe and raising awareness of science-related topics around the world, informing decision-making, including political and ethical thinking). Furthermore, Reiss (2004) goes further to consider the aims of science education as having the potential to improve the world, helping students to strive for social justice. Developing the arguments of Reiss (2014), White (2008) and Harlen (2018), my thesis is underpinned by the belief that moving beyond a science education focused on knowledge outcomes, must start at the primary level in order to develop the educational processes needed to better equip future citizens.

1.3 The current status of primary science education

The most recent National Curriculum in England was released in 2013 (DfE, 2013). As Waller (2017) articulates, it dictates **what** should be taught, but not **how** to teach it, leaving schools with the flexibility to extend and include additional content. That said, in agreement with White (2008) and Kelly (1985), a focus on the content within the programmes of study could have an influence on the way teachers understand science. Along with Roberts (2019), this thesis begins with agreeing that through supporting beliefs and pedagogical approaches, there is an opportunity for teachers and schools to take ownership of the science curriculum. However, as highlighted by Alexander (2012), as the science National Curriculum is reinforced by assessment requirements in the form of teacher assessment descriptors and biannual sample tests, it can be reasonable to assume that a significant proportion of schools and teachers will focus on these outcomes. As articulated by the DfE (2013), the current science curriculum has a stronger focus on the importance of science knowledge and language and a greater emphasis on core science concepts underpinning pupils' understanding with the aim of competing with high-performing jurisdictions, such as Japan, Estonia, Finland and Canada (Schleicher, 2018). In response to recent Ofsted (2019) findings, it could be argued that these changes do not support the challenges faced in bridging the gap between school science and real-world science, enabling young people to understand the role and uses of science as global citizens.

Across Key Stages 1 to 4, the National Curriculum for science aims to ensure that all students:

- Develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry, and physics
- Develop understanding of the nature, processes, and methods of science through different types of science inquiry that help them to answer scientific questions about the world around them
- Are equipped with the scientific knowledge required to understand the uses and implications of science, today and for the future (DfE, 2013:3).

Despite the third aim aligning with the purpose of the research thesis with a specific focus on global learning, this study is motivated by the need to explore how children can be supported not only to understand the uses and implications of science, today and for the future, but also to promote the values and attitudes of a global learner (as identified by Oxfam, 2015): self-awareness, a commitment to equity, respect for other ideas, value for diversity, a commitment for sustainable development, inclusion and teamwork, as well as a sense of agency to use science responsibly as global citizens. Whilst important across the science curriculum, this thesis will focus on how these aims are translated into the primary programmes of study (DfE, 2013), teacher assessment frameworks (DfE, 2018), professional standards (DfE, 2011) and how well this is implemented in practice. As identified by research conducted by the Royal Society (2010), children form their attitudes towards science in early primary science, having an impact on how they see and use science in the later stages of their education and life. This underlines the importance of exploring a global learning approach to primary science education.

1.4 Research rationale

There is no doubt that science education is valued in Europe and internationally (CasE, 2015; NSTA, 2017; European Commission, 2020). Governments globally recognise the importance of science education to their citizens and society (Fensham 2008; European Commission, 2015), however personal experience suggests that a greater focus on the role of Initial Teacher Education (ITE) and Continued Professional Development (CPD) could have a greater impact on its profile within primary education.

The process of 'working scientifically' used within the primary science curriculum for England (DfE, 2013) is in line with constructivist principles (the active acquisition of new knowledge through the process of building on prior experiences and ideas, as explored by Driver et al, 1994). In agreement with McCrory (2018), through 'working scientifically', children are enabled to explore ways to investigate and test out their ideas and questions by making observations, gathering data, presenting their findings and then explaining what they have found out scientifically. Within teacher training provision, as identified by Newton (2013) and Wellcome Trust (2017b), there is a strong emphasis on scientific thinking and inquiry-based learning, which underpins 'working scientifically'. Scientific thinking and inquiry-based learning, which enable children to think critically and creatively about the world around them (Winterbottom and Winter, 2017) has much to offer in terms of nurturing scientifically literate citizens for a global society.

Building on the work of Dewey, this thesis is motivated by the belief that it is now time to consider how science education, through 'working scientifically' not only nurtures the next generation of scientists and scientifically literate individuals, but also supports citizens of the global community to participate and act responsibility in a knowledge society (UNESCO, 2016). This links closely to the recent research advocating a 'science capital' teaching approach (Godec, King and Archer, 2017) which encapsulates all science related knowledge, attitudes and experiences to find meaning and relevance in science beyond exams and science careers. Consequently, research into a global learning approach, an approach which is global in its awareness, interdependence and application, could inform a science education which uses scientific thinking, enquiry and inquiry-based learning to raises science capital and nurtures responsible and informed global citizens simultaneously.

1.5 The challenges faced in delivering science education in primary schools to develop global citizens

Strong evidence from the Wellcome Trust (2017a:51) indicates that 'teachers value science learning and acknowledge the transferrable nature of science learning to other subjects'. This is also supported by Hast's (2017) research which indicates teachers' appreciation of science's importance in primary education. However, teachers face many challenges in the subject's delivery. Research highlights the unsatisfactory amount of time available for teaching science within the timetable often leads to a reductive approach to the curriculum coverage which focuses on knowledge (CIEC, 2018), rather than the understanding, reasoning and literacy of science, identified by Braund and Reiss (2007). Hast's (2017) research also suggests further exploration is needed in the motivation and values of teachers and the impact on children's science learning.

As a result of high-stake accountability testing in English and mathematics, these subjects have taken priority in senior leadership agendas, as addressed by Hast (2017:135). This is reflected in school development plans, team meeting foci, timetable quantity and professional development. Thus, despite being a core subject, science is often perceived as a low priority in primary schools and in many cases, is relegated to foundation subject status. This discernment is reflected in both Ofsted commentary (2018), as well as in initial teacher training programmes (Wellcome Trust, 2018). In the eyes of Foucault (1977), this has resulted in a subject being removed from the panoptic gaze, affecting the potential for development of the subject area.

Despite teachers feeling a sense of satisfaction in their teaching of science, the majority have only studied science up to the equivalent of GCSE level. As a result, combined with the lack of subject specific Initial Teacher Education (Wellcome Trust, 2017a), teachers lack confidence in answering children's questions, which, as discussed earlier, is the basis of constructivist, inquiry-based learning (Wellcome Trust, 2017a), and the foundation of a science education that will support global citizens. The government's 'teacher assessment framework' (DfE, 2018) only accounts for children at the end of each key stage, often resulting in concentrated science teaching in Year 6 and Year 2, rather than a

gradual accumulation of knowledge and skills over children's primary school experience (CIEC, 2018). The lack of teacher confidence and accountability may inhibit the development of a science curriculum which nurtures a global learning approach, adhering closely to the statutory requirements. Exploring teacher agency, which can be defined as teachers demonstrating the capacity to actively respond to dilemmas, problems and opportunities in order to make decisions and actions for the long-term development of their learners (Priestley, Biesta and Robinson, 2015) will be an important element of this study.

As well as teacher agency, another challenge faced by primary schools is the lack of equipment and materials to pursue practical work and investigations, leading to the reliance of worksheets and video clips (Ofsted, 2018). However, even when practical work in science is pursued, the Ofsted commentary (2018:5) suggests that it is carried out with no impact on children's learning, due to a 'piecemeal' approach and a struggle to build a science curriculum which is relevant to global citizens. Abrahams and Miller (2008, p.1967) confirms that an emphasis on constructivist and inquiry-based learning can result in practical work becoming 'hands-on' but not 'minds-on'. Ensuring that teachers allocate time to helping children use and apply ideas linking with the outcomes of their practical work and investigations is, therefore, a major challenge, and a motivation for this research study. The role of a global learning approach will, therefore, be explored in order to combat the challenges outlined.

1.6 The rationale for a global learning approach to science education

Sustainable Development is widely accepted as referring to 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' with the aim of bridging the gaps between environmental, economic and social concerns (UNESCO, 2014a). An understanding of basic science concepts and skills is arguably fundamental to understanding the complexities of our planet, underpinning sustainability literacy and action, however Vouloulis (2019) argues that science knowledge is not sufficient. Kioupi and Voulvoulis (2019), identify that the complexity of sustainability as a concept makes it challenging to translate into educational learning outcomes. The Sustainable Development Goals Agenda of the United Nations (UNESCO, 2015a) provides a framework of universally accepted actions to help our global society to achieve justice, prosperity and environmental security. However educational strategies and policies for implementing an Education for Sustainable Development (ESD) are less clear. With the overwhelming nature of the sustainability concepts, a misconception that sustainable development will be taught elsewhere in the curriculum, and a lack of supporting guidelines, the impact of ESD is limited. It is, therefore, fundamental to explore how teachers understand, interpret and internalise sustainable development principles in order to have successful effect on classroom practice.

Scoffham (2018: 135) agrees that global learning as an 'evolving and contested area of the curriculum' presents teachers with considerable challenges. Bourn (2016) acknowledges that whilst learning about the wider world is not a new phenomenon, concepts such as 'global learning', 'global citizenship

education', 'development education', 'Education for Sustainable Development' and 'global education' have become prevalent in education discourse and practice and have become established in national and international policy (O'Flaherty, 2018; Franch, 2019). Increased popularity of these terms in education also brings ambiguity and different understandings within and across a variety of contexts, (Oxley and Morris, 2013; Standish, 2014; Bosio, 2021). Andreotti (2010:240) and Pashby (2016) agree that words such as 'global', 'citizenship' and 'education' do not represent reality but have different interpretations in a variety of contexts according to shared worldviews and cultural assumptions, therefore representing a variety of meanings. Exploring such interpretations will, therefore, aim to support a deeper understanding of the motivation to consider global learning within the context of primary science education.

1.6.1 A question of purpose

Biesta (2013), in discussing the purpose of education, identifies three domains which are useful when considering what kind of education is needed for a global citizen. As a 'qualification', education can be considered in terms of ways in which it qualifies students to do certain things, as 'socialisation', it can be related to the ways in which individuals can become part of particular traditions and practices, and finally, as 'subjectification', education can be thought of as that which enables individuals to become 'agents of their own actions,' (Biesta, 2013: 739). These domains, as Biesta (2020) points out, cannot be separated and have a complex relationship, but from a 'global learning' and 'global citizenship education' perspective, they can be used to raise the question of what it means to teach knowledge and skills, and 'what it does to and requires from individuals' (Biesta, 2020: 102).

As a 'qualification', the purpose of Global Citizenship Education can be seen as facilitating the acquisition of a certain set of knowledge, skills and dispositions (often referred to as global competencies) where the purpose is about producing effective members of a global economy driven by capitalism and technology (Bosio, 2021). It could be argued that this can be seen in the OECD PISA 2018 Global Competence Framework (Franch, 2019) in which global competencies are based on a prescriptive set of knowledge, skills, attitudes and values and a proposed set of criteria through which to assess them. This discourse aligns with the concept of neoliberalism which argues that competition should be the driving force of the economy, and thus acquiring global competencies will prepare learners for the global society and allow them to compete for jobs in the global economy. Mannion et al (2011) suggests that an enhanced profile of Global Citizenship Education in some national policies is a response to a desire to compete in the global economy, preparing young people to face the threats and take advantage of globalisation. Huckle (2017) agrees that government support for global learning could be seen as an opportunity to prepare students to succeed in a consumer society. Within this discourse, the disciplinary knowledge and skills within science are seen to develop the next generation of scientists who can complete in the global economy.

As ‘socialisation’, Global Citizenship Education can be seen as a focus on promoting certain values and identities to become ‘good citizens of the world’, fostering citizens who are committed to a world culture based on human rights, peace and cohesiveness, environmental protection and sustainability (Sant et al, 2018). An example that reflects this discourse is the UNESCO’s Global Citizenship Education Pedagogical framework (UNESCO, 2015) in which a global citizen is defined as ‘informed and critically literate, socially connected and respectful of diversity, ethically responsible and engaged’ (UNESCO, 2015: 20). This discourse aligns with the concept of cosmopolitan humanism in which, from a GCE perspective, focuses on fostering respectful and responsible citizens. In line with this discourse, GCE is criticised for having an implicit ‘colonial’ approach and failure to critique or address the neoliberal agendas. Bourn’s (2016) research, for example, has also shown that related terms such as human rights, climate change and sustainability have been treated as themes for lessons, rather than a pedagogical approach. As Andreotti (2006) warns, learning about global issues and different cultures as topics in science can lead to a ‘soft’ uncritical approach to global learning, reproducing the misconception of Western supremacy. Andreotti (2012) warns that global citizenship education without critical analysis of power relations and global inequalities can result in reproduction of approaches that reinforce ethnocentrism.

As ‘subjectification’, Global Citizenship Education can be underpinned by the values and knowledge of critical pedagogy and social justice. Andreotti’s post-critical GCE is an example of this, in which learners are not provided with prescribed ideals of democracy, freedom, rights and justice, but facilitate the emergence of ethical, responsible and responsive ways of seeing, knowing and relating to others (Andreotti, 2010: 239). This discourse aligns a social-justice activism with a radical and transformative view of global citizenship, based on a critical and empowering pedagogy. Influenced by the work of Freire (1994), it attempts to move beyond learning about global issues, to a critical engagement with them, enabling learners to become critically literate and committed to act to achieve democracy, equality and social justice within the local and global community.

In reflection of these overlapping domains, Biesta (2020) acknowledges that despite ambitious aims to support students in the development of knowledge, skills, attitudes, values and ways of being as global citizens, this entails a risk in terms of how these aims are interpreted, implemented and utilised by the student. A large part of educational research and policy is aimed at reducing these risks, which is perhaps why the OECD developed a global competencies framework, to ensure there was a framework for intended skills, knowledge, attitudes and values. However, this can remove any space for sense-making, exploring new ideas, or, as Biesta (2013:742) explains, allowing individuals to ‘become subjects of their own actions and responsibility’. From a global citizenship education perspective, Biesta (2020: 89) therefore suggests that the purpose of education should be to support individuals to develop the ‘freedom to act in and with the world in which they live’.

1.6.2 Global knowledge and skills

Even when Global Citizenship Education is accepted as a route to a better future and common good, its introduction into the curricular raise questions about the kind of Global Citizenship Education that is suggested and implemented. Nationalism, neoliberalism and confusion of meaning remains a barrier to the development of a global education (Tye, 2014). It is these factors, along with the deep structural forces in each country which prevent attempts to move away from past curricular.

The nature of disciplinary knowledge in the curriculum is important to address. Standish (2017) argues that education which addresses global issues is eroding the boundaries that give meaning to the academic knowledge, skills and ethics in the context of education. Standish (2017) states that the pursuit of truth is what distinguishes disciplinary knowledge from everyday social and cultural knowledge. This line of thought is supported by Young (2008) who underscores that the primary purpose of education is for students to gain access to different specialist fields of knowledge. Wheelham (2010) argues that knowledge is no longer valued in its own terms but treated as a means to achieving some other aim. I would argue that disciplinary knowledge is not undermined by extrinsic aims but strengthened by them. In agreement with Pike (2000:64) who suggests we should view global education as a 'pursuit' of meaning, a global learning approach can give meaning and purpose to the development of generative disciplinary knowledge and skills. Developing a clear understanding of subject knowledge allows for the accumulated wisdom of the past, enabling children to understand relationships, patterns of behaviour and theories about phenomenon which allow them to make sound judgements and actions in the world. In primary science education, for example, a global learning approach would ensure purpose and meaning were restored in learning that is often currently lacking purpose (Bianchi, 2021).

1.6.3 The context of global learning

Global Citizenship education has also been criticised for missing the important reference to communities and nations (Standish, 2012). Community-based activities, which provide a specific context and environment to think about, respect local and indigenous knowledge, enable creativity and support citizenship. It is important, therefore, that learning (science learning in the context of this thesis) is rooted in local communities, giving meaning and substance to global ideals, valuing interdependence and openness to difference. This relates to Reiss and White's (2014:8) recommendation for the curriculum to have three main aims: to enable each learner to lead a life that is personally flourishing, to help others to do so, too, and to have a 'background understanding'. Reiss and White (2014) argue that without an understanding of human nature, of our social life and how it has developed as it is, and of the natural world in which we live, it is difficult to situate ourselves both in time and space. I would agree that the understanding of our own nature and how we are connected to the rest of the living world (both scientifically and culturally) have implications for how we cooperate and collaborate as global citizens now and in the future.

1.6.4 A case for a global learning approach to primary science education

Critical engagement with Global Citizenship Education provides an opportunity to challenge the reproduction of a 'colonial hierarchies and hegemonies' (Stein and Andreotti, 2016:230). However, Goren and Yemini (2017) argue that these opportunities are constrained by the context of the schools and formal education structures. The UN's 2030 Agenda for Sustainable Development outlines bold goals that universal education can help to meet. Whilst acknowledging the constraints of working within formal education and the need to shift theoretical positionings to meet these contexts, pedagogical tools can support and guide teachers. Bosio (2021) proposes that along with the UN's 2030 agenda, a critical framework informed by values of critical pedagogy ingrained in social justice is required. Disciplinary knowledge and skills alone are not enough. A sustainable global society requires children to gain the knowledge, capacities and dispositions required for them to use the disciplinary knowledge. I would argue that a global learning approach to a subject can provide a key role in giving students the space to understand themselves and others in relation to place, time, belief, identity and culture.

1.6.5 Global learning as a pedagogical approach

Until recently, less attention has been given to global citizenship education as an approach to teaching and learning. The above critical analysis of global citizenship education highlights the importance of considering how global learning can be embedded within the curriculum. I would argue that as a pedagogical approach, global learning can avoid the challenges related to nationalism, neoliberalism and confusion of meaning through embedding these four main principles into our teaching and learning:

- Critical and creative thinking
- Self-awareness and open-mindedness towards difference
- Understanding global issues and power relationships
- Optimism and action for a better world.

As Bourn (2016) suggests, this requires consideration of how global learning can be embedded within individual subjects. Whilst a cross-curricular approach can be successful (Golden, 2016), I would argue that there is also a need to consider how a global learning approach can be brought to individual subjects which are often delivered discretely within the formal curriculum.

1.6.6 Supporting educators to develop a global learning approach

Whilst the above critique suggests the potential benefits of a critical global citizenship education, the difficulties teachers face when implementing such goals are often neglected. Stein (2018) highlights that in order to prepare students with self-reflectivity, intellectual curiosity, historical memory and a deep sense of responsibility needed to navigate an uncertain future, educators need to be able to engage confidently with a range of conflicting perspectives so they can make critically informed, socially accountable pedagogical choices that are responsive to the complex shifting conditions and challenges

within their own contexts. This requires us to consider the professional learning we can implement to support the development of our global citizenship educators.

1.7 The role of global learning in promoting a primary science education fit for purpose

As articulated, a global learning approach aims to support global learners who develop the 'freedom to act in and with the world in which they live'. If science is seen as an ever-changing body of knowledge, driven by uncertainty, discovery and questioning (Hoath, 2020:3), then global learning could be an important approach towards science education, informing active and responsible global citizens. In an analysis of the vision of science education (and specifically primary science) within key professional organisations in England, the aims discussed above were highlighted, as can be found in Table 1.1 below. It is evident that these overarching visions suggest the importance of all children receiving an exciting, inspiring and relevant science education at primary school that leaves them well-prepared to progress further in science, and well informed about science in their daily lives and global society, using terms such as 'informed decisions about themselves and their world; shape our future for the better; discover why science matters in the world'. Despite these key professional organisations, along with researchers, educators and policy makers showing a greater interest in global learning within school curricula, a tension often exists between national education priorities and the global learning approach described above. As underscored by Andreotti (2014), many of these organisations may project Western values and interests, founded on a technocratic approach to educating citizens. Andreotti (2014) advocates an interrogation of epistemological assumptions in order to ensure a vision of science education engages learners in fostering a sense of global cooperation rather than competition.

In agreement, within my own practice as a primary science teacher, teacher trainer and professional development facilitator, I have observed and evidenced some engaging examples of global learning dimensions in primary science classrooms. Unfortunately, a global dimension is certainly not explicit in the Primary Science Programmes of Study in England (DfE, 2013), and therefore left to chance.

Table 1.1: A summary of key aims identified by significant national and global organisations influencing science education

Organisation	Vision
The National STEM centre	To achieve a **world-leading STEM education** for all young people across the UK through: ● Young people from all backgrounds have the aspiration, knowledge and skills to thrive, with more progressing into STEM-related careers ● Employers can gain access to knowledgeable, talented people with strong STEM skills, increasing productivity, competitiveness and diversity ● Teachers of STEM subjects continually develop their STEM knowledge and experience, maximising their impact and own job satisfaction

	● Families and communities recognise the value of STEM to young people, encouraging and supporting them in STEM-related studies and careers STEM Learning Ltd (ND)
Wellcome Trust	Science should be exciting for young people, giving them skills and opportunities to **improve their futures and discover why science matters in the world**. ● Primary school teachers given the skills, knowledge, confidence and passion they need to improve primary science teaching. ● All teachers should have access to continuing professional development to keep up-to-date with the latest research and ways of teaching in order to create high-quality inspirational lessons. Wellcome (ND)
Organisation for Economic Co-operation and Development (OECD)	Science education in the primary grades aims to capitalize on curiosity and starts young students on a path of **systematic inquiry about the world in which they live**. As their understanding of science develops, students in the lower-secondary grades become increasingly able to make **informed decisions about themselves and their world** so that, as adults, they can become informed citizens capable of distinguishing scientific fact from fiction and understanding the scientific basis of important social, economic, and environmental issues. Across the world, there is an increased demand for those qualified to pursue the careers in science, technology, and engineering that **drive the innovation necessary for economic growth and for improving quality of life**. To meet this demand, it is increasingly important to prepare students to enter advanced study in these areas. OECD (2018b)
British Science Association	A future where **science is at the heart of culture and society**, instead of set apart from it. Science education's purpose to be for creating a society which is comfortable with science and excited by discovery, not just training a scientific workforce By unlocking the potential of a more diverse group of people, we increase our ability to tackle some of the **world's biggest challenges** and shape our future for the better. British Science Association (ND)
The Royal Society	Vision: The ability of people to **understand the world** in which they live and work depends on their understanding of scientific ideas and associated technologies and social questions. Science and mathematics education should enable people to make informed choices, empower them to shape scientific and technological developments, and equip them to work in an advanced economy. Inspirational mathematics and science lessons should be at the heart of the curriculum, and there should be an emphasis on practical work and problem solving. Royal Society (2014)
The Royal Institution	Vision: **A world where everyone is inspired to think more deeply about science and its place in our lives**. Mission: Building on our heritage to create opportunities for everyone to discover, discuss and **critically examine science and how it shapes the world around us**. The Royal Institution (ND)

Subsequently, global dimensions (such as global contexts, critical and creative thinking, self-awareness and open-mindedness to difference, and understanding of global issues, as identified by Bourn,

2016) are not reflected in the reality of primary science teaching and learning in England. Whilst the National Curriculum (DfE, 2013) advocates the importance of developing science conceptual understanding through the skills of 'working scientifically', the challenge is to underpin this concept and skill development with their relevance and use of science in their global society. In order to do this, this thesis explores how practitioners can be motivated to pursue sustained professional learning in primary science, considering the global dimensions of the subject, and adding it to the prioritisation of primary school development plans and policy agendas. This rationale explains the important role of global learning in ensuring primary science education is fit for purpose, underpinning this study. Primary science education should be reflective of the global nature of the subject, supporting children to become responsible, scientifically literate, global citizens, through purposeful enquiry. Understanding how both policy and practice enables us to do this will underpin this thesis.

1.8 Researcher Positionality

As a primary education professional for the past 15 years, I have had the opportunity to teach and observe primary science within a range of settings and systems including independent schools, international schools, and government funded schools. My experience has also extended to consulting government education teams, designing primary science courses for ITE programmes, planning and delivering professional development for leaders in primary science, as well as conducting practitioner research in the area of global learning in primary science education.

My professional role as a senior lecturer in primary science education and lead facilitator in STEM CPD has given me a platform through which to work with schools and teachers to explore their attitudes and approaches to primary science and global learning (as part of this research project). During my research, whilst working with teachers and trainee teachers to consider pedagogical approaches towards their primary science teaching and learning, I have had no direct role in terms of classroom teaching. Through my prolonged immersion in the classroom, however, specifically teaching science, I have had access to insider perspective, whilst maintaining a distance from participant practice. This enabled me to establish a trusting rapport, in which participants were able to be honest about their attitudes and practice, without feeling judged.

Throughout my research, I am aware that my personal values and professional philosophy are at risk of influencing my data. However, the myriad of experiences as a leader in primary science education may also be seen as a strength; enabling me to consider a wide spectrum of needs and challenges in the development of primary science in different schools. There is an inclination for me to focus on the schools and teachers who were readily enthusiastic about integrating a global dimension to their primary science curriculum. To ensure I maintained open to pedagogical beliefs and systems that do not resonate with my own views, I endeavoured to work with a broad range of respondents that would support a more critical examination of policy, systems and attitudes that influence the development of a primary science curriculum. Fundamentally, I carried out a mixed-methods, pragmatic position

through which I will strove to understand the participants in order to reduce the propensity of replacing my own experiences; thus, maintaining an awareness of the current reality.

I also wanted to ensure that I avoided the mistake of 'confirmation bias' during the data collection stage of my research. It was, thus, important to keep the essence of complexity perspective, keeping an open mind and constantly checking against multiple perspectives as a form of triangulation (interview data, surveys, reflective diary and teacher notes) in order to avoid researcher bias. Considering the challenges faced in primary science education will, therefore, underpin an awareness of the perspectives that need to be considered during the thesis.

1.9 Significance of the study

Through my role in teacher education, and the ever-changing climate of its provision, it is central that my research can inform the way in which trainee teachers and practising teachers are supported to deliver a science curriculum which fosters global learners, supporting the development of ITE undergraduate and postgraduate science teacher training provision. It is also important that within a community of practice (defined by Wenger, 2000, as a group of people who share a passion for something they do and learn how to do it better), my colleagues and I can support each other to challenge the way teacher training is delivered, to ensure that science education provision nurtures global citizens of the future. Global learning is an emerging area of study with evolving terminology, therefore, as highlighted by Bourn, Hunt and Bamber (2017) there is a need to develop a clear conceptual framework to measure the progress of global learning within initial teacher education. My position within Initial Teacher education (ITE) and CPD will enable me to support colleagues in understanding their role in nurturing global learners within the context of science education.

The research findings may challenge approaches to science-specific Continued Professional Development (CPD), primary science ITE and primary science methodology. With the potential benefits of increased teacher engagement, confidence and enthusiasm, attainment and engagement in primary science, as well as the development of global competencies (which will be assessed internationally), this research has the potential to influence policy and curriculum leadership. The research also aims to give guidance to lecturers to embed global learning in primary science ITE modules. The research will aim to explore a new approach to learning science and related policy, motivating children in an education for their global future.

1.10 Research Scope and Contribution to the Field

The research will focus on primary science in England, although the findings may be of significance internationally, both from a policy and practitioner perspective. It must be acknowledged that, as with most educational research, the generalisability of findings will be reduced by the unique nature of the schools, teachers and children that participate. That said, there is limited literature and research around

global learning within the context of primary science education, along with related teacher engagement and attitudes. As a result, this study will contribute to literature.

Time constraints will naturally impact on the overall findings, as any paradigm shift related to pedagogical approaches may take longer than the duration of this thesis. That said, the dynamic and reflective nature of this study will run beyond any thesis submission, acknowledging the importance of continual, reflexive change in primary science education. Primary science education is the main field I will be contributing new knowledge to, especially in the context of England.

1.11 The underpinning framework of the thesis

This thesis aims to examine the extent, and the ways, in which global learning can be used to raise the profile of science in primary schools (and how primary science can provide a platform for global learning), engaging and motivating teachers and children alike. Using the definition of global learning outlined above, 'a pedagogical approach that puts learning in a global context, fostering critical and creative thinking, self-awareness and open-mindedness towards difference, understanding of global issues and action and optimism for a better world,' the research will explore three main constructs: how **subject-specific global learning professional development** can be conducted to support value and confidence in primary science teaching; how and if **global learning** can be embedded in the primary science curriculum; and, whether a global learning pedagogical approach supports **teachers as agents of change**.

To address these aims, it is important to consider the levels of research analysis:

Macro level: Policy Context
To consider the implications of this study to inform primary science education in a policy context and consider its ability to nurture global citizens;

Meso Level: Training Providers/School Links (partnership/CoP)
To consider ways in which a global learning approach can be used by training providers of teacher preparation and ongoing professional learning of primary science education;

Micro: Pedagogy and purpose (processes)
To explore at the level of the school how teachers might develop professional autonomy in their use of the primary science programmes through embedding a global learning pedagogical approach;

EdD: Informing professional practice
To consider how recommendations from this study (and the professional development tools developed within it) might be used within the practice of teacher educators, teachers and leaders of primary science education.

1.12 Research questions

Drawing these research aims together, the overall research question for this study is: '**To what extent, and in what ways, does a global learning approach develop the purpose and value of science in primary schools?**' Given the nature of government policy, evaluation and the structure and processes of schools, how far can global learning influence a change in professional practice and values?

In order to address this overarching research question, the subsidiary research questions are:

1. *In what ways do stakeholder beliefs and attitudes to global learning in primary science influence their engagement with the approach?*

2. *How can a global learning approach to primary science be integrated into ITE and professional development?*

3. *In what ways does a global learning pedagogical approach support greater motivation and engagement with the primary science curriculum?*

1.13 Overview of the thesis

The structure of the dissertation will be as following:

As the study tries to understand how we can empower teachers to engage with and deliver a global learning approach to primary science, two key themes are explored: pedagogical beliefs and attitudes and models of professional development in primary science education. These will be explored as separate constructs in the literature review but drawn together in the discussion to answer the research questions. Chapter 2 and 3 review of literature relevant will inform the conceptual framework fundamental to the design and implementation of the thesis.

Due to the two discrete fields involved in this study; global learning and primary science education, the literature review will aim to draw on the gaps in both areas and demonstrate how global learning can be used as a pedagogical approach to deliver primary science education, and vice versa.

Chapter 4 discusses the main rationale behind the use of global learning as a pedagogical approach to science teaching and how the current study was presented. Followed by the outline of the development process or procedure that was used in designing and integration of global learning in primary science in the English school environment. Chapter 5 presents the methodology used to investigate the impact and effectiveness of global learning as a vehicle to raise the profile of primary school science teaching in England. Chapter 6 and 7 presents the analysis of data. Quantitative data

will be used to establish attitudes towards global learning as an approach to support primary science teaching and learning. Qualitative data from a research reflective diary semi-structured interviews and evidence of implementation of the global learning approach in three case study schools will then be drawn upon to explore the barriers and opportunities in relation to its implementation.

As two separate constructs were considered (professional beliefs and professional development in primary science), these are addressed in two separate chapters. Chapter 8 presents the discussion of the results, with findings of the current study for all the research questions, and presentation of recommendations that have significance for ITE and CPD providers, policy makers and teachers. Chapter 9 provides the study conclusion, including a summary of the results obtained in this research. Finally, the chapter reviews the strengths and weaknesses of the current study in order to add important recommendations and proposals for implications for future research in this field, as suggested by the findings.

CHAPTER 2 LITERATURE REVIEW: SCIENCE-SPECIFIC PROFESSIONAL DEVELOPMENT

2.1 Introduction

As outlined in the first chapter, this thesis considers how global learning, as a pedagogical approach, can support stakeholders to reconsider the purpose of primary science education. With a focus on its implementation, Chapter two considers how an informed approach to professional development can lead to a better understanding of global learning as a pedagogical approach, exploring how it can be incorporated in the context of primary science education. It will look at the purpose of professional development, some examples of science-specific professional development models, followed by a synthesis of successful practice. This will be used to inform the global learning pedagogical approach to primary science.

2.1.1 The purpose of professional development

Effective professional development can be defined as 'structured professional learning that results in changes in teacher practices and improved learning outcomes' (Darling-Hammond, Hyler and Gardner, 2017: v). It is viewed as pivotal in the preparation of trainee teachers for further education and work in the twenty-first century (Darling-Hammond et al, 2017). Increasingly seen from a lifelong learning perspective (OECD, 2019), and underpinned by a teacher's values and beliefs (Biesta, Priestley and Robinson, 2015), professional development is unique to every teacher. 'Teacher beliefs' is a term used frequently to explain choices in classroom practice underpinned by the wider-purpose of education, as highlighted by Biesta, Priestley and Robinson (2015).

Shulman (1987) identified seven knowledge bases specific to teachers – content knowledge, general pedagogical knowledge, curriculum knowledge, knowledge of characteristics of the learner, knowledge of educational goals, knowledge of educational contexts, and Pedagogical Content Knowledge. With a focus on the extent to which global learning can be used to raise the profile of primary science education, all of these knowledge bases must be considered and challenged in order to consider how teachers (and other stakeholders) can make authentic connections between these two constructs. Consequently, effective professional development is imperative to support teachers to develop and refine pedagogies appropriate to support our future global citizens.

Pedagogical Content Knowledge (PCK) and curriculum knowledge will, however, be a main focus of this study. The following section will define what PCK and curriculum knowledge are, why they are so important and the reason they are the main foci for this particular study. As defined by Chordnork and Yuenyong (2018:1), PCK is the 'amalgam of content knowledge and pedagogical knowledge that leads to learner understanding', which is unique to the individual idiosyncrasies and differences that influence teaching content, context and experience. As Bayram-Jacobs, Henze and Evagorou (2019) state, PCK is a necessary body of knowledge for science teachers to apply educational reform, thus having a strong PCK for science may enable practitioners to implement a new approach more successfully. Given that

PCK is accepted as an essential knowledge base for teaching science, it is important to investigate how primary teachers' PCK can be supported through, and support, a global learning approach. Curriculum knowledge, as defined by Shulman (1987) can be described as a practitioner's broad comprehension of a subject (in this case, science) with an awareness that there are different ways to structure a curriculum, and an awareness of the various instructional materials, teaching procedures and learning objectives within it. Exploring the blend of these two knowledge bases will aim to explore how practitioners can be supported to consider global learning as a pedagogical approach to primary science education.

2.1.2 Building a Community of Practice

Another important aspect of professional development is the idea of building a Community of Practice (CoP, Lave and Wenger, 1991). A CoP can be defined as a 'set of relations among persons, activities and the world, over time and in relation with each other tangential and overlapping communities of practice' (Lave and Wenger, 1991: 98). They argue the importance of 'interaction and social discourse allowing for interpretive support for sense making' (Lave and Wenger, 1991: 98). Thus, whilst this thesis focuses on the professional learning of the individual professional, it must also acknowledge the importance of context in order to understand how learning and professional development is experienced and conceptualised. In relation to the notion of CoP, considering how individuals support each other towards a global learning approach will be an important aspect of this study. For the remainder of this thesis, I will use professional learning as the key umbrella term, conveying the view I hold.

As a result of the limited literature related to professional development in global learning in primary science education specifically, this chapter will continue by reviewing subject-specific professional development literature, focusing on primary science education in England, and international comparisons, along with limitations of any recommendations that emerge from previous studies. I will then demonstrate how some of these recommendations have influenced a range of professional development models within primary science education, developed to conceptualise the complexity of teacher professional development. These will be explored and compared to develop an understanding of the micro-level (individual teachers), meso-level (school context) and macro-level (wider professional structures and policies). Whilst not focusing on global learning in this section, I am going to discuss how professional development influences a teacher's practice and in Chapter four, I will use this understanding to consider how it specifically relates to a global learning pedagogical approach.

2.2 Professional development in primary science

Science in primary schools in England, similarly to most other countries around the world (DfE, 2015), is still usually delivered by classroom teachers. Approximately half of all UK primary schools hold dedicated science weeks (Wellcome Trust, 2019), with many organisations supporting and funding these events. However, when these weeks are combined with the time dedicated to science teaching

on a weekly basis, the total amount of science taught throughout the year equates to, on average, 1 hour 24 minutes of science per week - less than the recommended two hours of science per week for all year groups (Wellcome Trust, 2017a). A recent research study by Ofsted (2019) found that primary science, whilst being a core subject in the National Curriculum of England, often had weakness in curriculum design. Their report indicated that weakness in areas such as leadership, breadth and depth, and planning for progression were the result of a greater focus on English and maths.

One explanation for the findings identified is the move towards teacher-led assessment in primary science, replacing 'high stake' national testing in 2009, as highlighted in chapter one. Whilst the previous testing regime was impacting negatively on the content of science lessons, forcing teachers to 'teach to the test', the current situation still has many challenges (Nuffield, 2012:2). Research has identified that many children and parents favoured the primary science tests, suggesting that they prepared them for secondary education (Wellcome Trust, 2010). Whilst a focus on teacher assessment aimed to provide more autonomy for the way in which science is delivered (Nuffield, 2012), high stake accountability tests in English and mathematics still result in a greater investment (in terms of both time and professional development) in these subject areas. Resultantly, teachers and schools may not have the capacity to develop and establish their own rich systems for measuring and monitoring children's progress in science. Moreover, without investment in professional learning, teachers and schools may not have the pedagogical insight to make changes to the way in which science is delivered.

Recent initiatives, such as Teacher Assessment in Primary Science (TAPS) (PSTT, 2020) and PLAN Assessment (PLAN, 2020), have supported a more systematic approach to assessment in primary science, helping teachers to understand what progression of knowledge and skills in science look like with moderated examples of children's learning. However, the multi-dimensional nature of science (considering the development of conceptual understanding and procedural skills) makes it challenging for teachers to track pupil progress (Earle, 2017). Schools and teachers need to track the security of conceptual understanding, the proficiency of skills and increasing independence and autonomy of scientific enquiries, which all need to be done simultaneously. Furthermore, whilst these are valuable tools to support teachers and schools, without the time and progression to develop PCK and a deeper understanding of how knowledge and skills are developed through the curriculum, such tools may not always be implemented successfully or systematically.

An Ofsted report from 2019 highlights that school leadership teams prioritise the development of subjects for which they are made accountable within their leadership goals and professional development focus. Primary science's current status (Wellcome Trust, 2019) means that professional learning in science may not be a priority and may not appear on the school development plan (Wellcome Trust, 2018). Subsequently, supportive systems which can be used to enrich a deeper understanding of how children can make progress in science, supporting greater teacher expertise, may be interpreted as assessment checklists. Engaging senior leadership of the importance of science and related

professional learning may be of great value. The next section considers the importance of science-specific professional development.

2.2.1 An argument for science-specific professional development

Teaching science is just one aspect of a primary teacher's role, but as a core subject, and as Serret and Earle (2018: 216) state, 'development and learning in science is an entitlement for all primary teachers and should be part of all teachers' professional lives and all schools' strategic plans'. Not only is learning science important for children's lives, whether they pursue a science-related career or not, but as most primary teachers do not have a science degree or A level qualification (Royal Society, 2010), teacher confidence in its delivery is often low. This is supported by the ASE (2019) which advocates the importance of subject-specific professional development as an essential component in maintaining high standards of quality science education. This, however, is largely the responsibility of individual teachers and schools, and is not often a priority on primary school development plans (Wellcome Trust, 2013; Hast, 2017; Turner, 2018), possibly due to the greater importance given to English and mathematics. The Wellcome Trust (2017a) highlights that only half of science leaders pursue external science specific CPD each year, despite being the main subject support for other teachers in their schools. Many opportunities across the UK, however, are available for high quality professional development in science for primary teachers, with large investment for the wider science community: such as the STEM learning network, ASE, Primary Science Teacher Trust, Wellcome, Primary Science Quality Mark, Royal Society of Chemistry, Ogden Trust, along with teach meets and university-based professional development. Effective CPD should be a collaborative, on-going process, relevant to the different stages of a teaching career, as Turner (2018) describes it, 'sustained professional learning'. How to get schools and teachers to realise, value and integrate these opportunities into their professional practice is the major challenge.

2.2.2 Considering how, why and what professional learning teachers choose

Exploring how and why teachers choose and pursue science-related professional learning in England is significant to the aims of this research. A recent study suggested that classroom teachers demonstrated a greater interest in and need for subject specific CPD (NFER, 2017). Unfortunately, this does not appear to be translated into practice, as highlighted by an international study (TALIS, 2013), which revealed that teachers engage in less Continued Professional Development overall, and less subject-specific professional development than most other high performing countries. A further report by the OECD (TALIS, 2014) conveyed that 50% of teachers in England reported 'effective' training over the previous year in their subject fields compared to an average of 71% for high performing countries. This indicates that both access to, and quality of subject-specific professional development, are areas of concern. The Wellcome Trust (2018) indicates that two main influences affect the demands for subject specific CPD: curriculum and assessment policy changes, and the prioritisation of the school leadership team. Barriers to the provision and development of high-quality subject specific CPD in

schools include lack of budget and resources, perceptions of poor quality CPD, teacher workload and completing improvement priorities (Wellcome Trust, 2018).

Findings (Ofsted, 2019) identified that much of primary school science planning was piecemeal with one-off activities or lessons without building a meaningful science curriculum. This thesis suggests that global learning as a pedagogical approach could support the construction of a cohesive science curriculum, helping professionals to plan with a wider purpose than discrete curriculum objectives. As defined by Priestley and Nieveen (2020:1), the curriculum includes the 'multi-layered practices, including infrastructure, pedagogy and assessment through which it is structured, enacted and evaluated'. Embracing subject-specific professional development to support the incorporation of this approach to science in primary schools will be a decision that senior leaders and teachers make along with multiple other pedagogical decisions. It is, therefore, paramount to this study to explore the factors affecting decisions for schools and teachers to invest in professional learning in primary science with a global learning pedagogical approach.

2.2.3 Engagement with subject-specific teacher training

After Initial Teacher Education (ITE), which can be undertaken through a variety of routes (including the university-based PGCE and apprentice-style GTP), subject-specific professional development includes keeping abreast of pedagogical and subject changes, as well as implementing educational reforms (government or otherwise-led), as Guskey (2000) explains. One aim of this research is a pragmatic concern with developing primary teachers' engagement with subject-specific development, through understanding the role of science within the wider world, and ultimately their role in ensuring it is fit for purpose, which underpins the global learning pedagogical approach. Thus, understanding how professional development is effective in influencing pedagogical decisions (from ITE to retirement) is vital.

Teachers' professional development as described by Guskey (1986) attempts to bring about change in the classroom practices of teachers, changing beliefs, attitudes and changes in learner outcomes. Fullan (1991), however, describes professional development as the totality of formal and informal experiences throughout one's career. Literature highlights the ambiguity of professional development (Evans, 2002; Friedman and Philips, 2004; Fraser, Kennedy, Reid and McKinney, 2007), but draws out two fundamental constructs: the understanding of professional development as a continual process, informed by the accumulation of experiences (which are mostly unplanned) and the understanding of professional development as an activity with purposeful and focused outcomes (which are usually planned). Much literature focuses on professional development as a focused activity. However, as highlighted in the research questions (see p.12), this thesis explores the approaches to professional development and the beliefs and attitudes which may result in changes to a practitioner's pedagogical practice. Subsequently, considering the role of individual attitudes and beliefs towards global learning on the implementation of the pedagogical approach in primary science, and the

experiences that impact on any changes to practice as well as attitudes towards professional learning, will be a focus of this study.

Kind (2009) suggests that some research indicates that a teacher's epistemological view of science is often a static body of content. This does not reflect my view of the dynamic, ever-challenging nature of science, and its role and relevance in addressing global concerns, as advocated by Billingsley (2020). This thesis argues that as global issues by nature are ever-changing, a global learning approach has the potential to support a greater focus on the process of learning developing practice, rather than the delivery of content. I would argue that considering the continual developments that change the way we live and interact with our world and beyond are fundamental to the engagement and delivery of science.

2.3 The history of science-specific professional development

To understand the changes in primary science education and related teacher education, it is useful to be aware of the dominant political educational ideologies influencing these changes. During the 1980s, teachers had autonomy over what they taught and how they taught it. During this time, teacher education relied on the strength and organisation of the local educational authorities and was described as opportunistic and fragmentary rather than planned (Furlong and Maynard, 1995). Although many opportunities for development of primary science teaching arose, such as the Nuffield Junior Science Project (as described by Dunne and Peacock, 2014), which encouraged scientific investigation, lack of organised dissemination meant that only schools involved in the initial projects benefitted.

The Education Reform Act (ERA, 1988) brought the introduction of the National Curriculum, with the elevation of science as a core subject. Whilst this ensured an increased amount of time dedicated to science teaching in primary schools, it also brought imposed uniformity and reduced autonomy (Littledyke, 1994). Further reduction of teacher autonomy resulted from the establishment of a list of competency standards, established in 1997 by the Teacher Training Agency (TTA), the Teacher Agency (TA) and National College of Teachers and Leadership (NCTL). As Hartley (1998) identified, the ITE curriculum along with the National Curriculum imposed on schools meant that both content and values were centrally established and audited through student tests and Ofsted inspections. The introduction of competency standards for all teachers in England (TDA) reaffirmed the marketisation of education policy and arguably the de-professionalisation of teachers.

In 2001, the first national strategy for teacher professional development (DfEE, 2001) was introduced, but as Pedder, Opfer and McCormick (2010) identified, the main purpose of CPD had changed from a focus on personal professional development of the individual teacher to supporting the achievement priorities targeted at policy implementation and its effective management. Further to this, National Strategies in Literacy and Numeracy (DfEE, 1998) provided frameworks detailing guidance for teacher methods. To help teachers plan science lessons, the Qualifications and Curriculum Authority

(QCA) published non-statutory guidelines in 1998, known as schemes of work (SoW). From 1991 to 1995, Standardised Assessment Tests (SATs) were introduced for 7- and 11-year-olds, which, along with English and Maths, were used to judge a school's performance as well as to evaluate science attainment. Although, as the Wellcome Trust (2013) highlights, effective assessment is integral to high quality teaching, teachers felt under pressure to focus on factual content, leaving little time to build on interests, engage discussion on science ideas and issues, and teach scientific enquiry (Parliamentary Office of Science and Technology, 2003). Ofsted was concerned that teachers were narrowing the curriculum to focus on SATs revision (Ofsted, 2002). As a result, the government abolished KS2 science SATs in 2009 and they were replaced by welcomed teacher assessment, as highlighted by Roberts (2017). Unfortunately, rather than having the intended benefit of increased enquiry and innovative teaching, current high-stake testing in English and Maths has resulted in science taking a low priority in schools, impacting on the uptake of professional development and subject-specific development.

In summary, until 2010, most professional learning was constrained to that focused on National Strategies and standardised assessment. This can be described as a deficit model, according to Kennedy (2005), in which professional development was prescriptive and government controlled. The White Paper, 'The Importance of Teaching' (DfE, 2010), had a key aim of supporting teachers to learn from each other and from evidence-based best practice. As a result of performance related pay (established by the DfE, 2013), which necessitated personal targets linked to whole school development targets, subject-specific professional development opportunities whilst widely available, were often *fragmented* (Wellcome Trust, 2018) and did not always reach those who needed them most. As there is a perceived lack of recognition of science as a core subject by many head teachers and school governing bodies (Ofsted, 2019) due to the accountability focus on English and mathematics, the result is less curriculum time, reduced budgets for resources and subject-specific professional development, and minimal or no investment in developing science as a subject. In response, the following section will explore three current national primary science professional development initiatives, and their impact, in relation to these issues.

2.4 The Primary Science Teacher Trust (PSTT) strategy of subject specific professional development

The PSTT strategy follows a flower model (Shallcross, 2015:9; Franklin, 2016) as depicted in Figure 2.1, in which science teacher fellows (emulating best practice) are the centre of the model, supported by academic collaborators. This aims to provide an evidence-base for the implementation of science innovation in the classroom, subsequently informing national and international policy. This model provides a potential solution to the commonly argued gap between educational research and practice, as highlighted by Hammersley (2007).

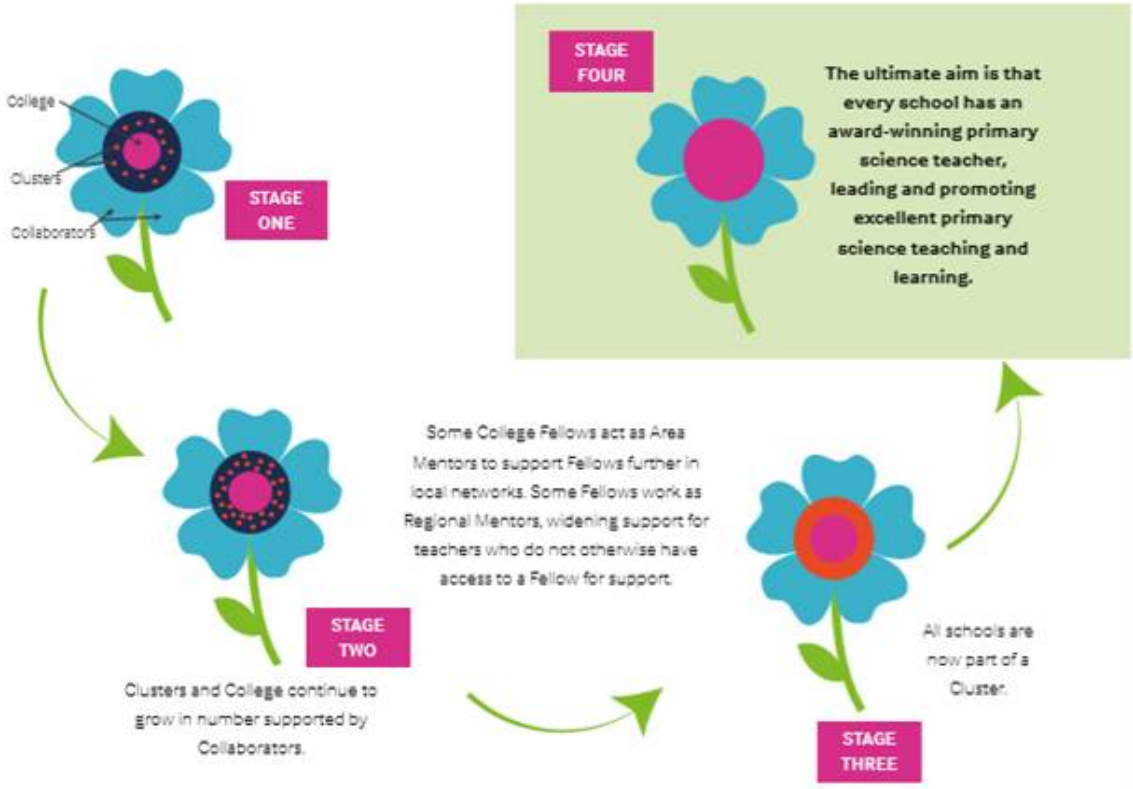


Figure 2.1: The flower model and its progression from a small number of clusters through to the completion of the model where all school clusters in the UK are engaging in excellent teaching of science at primary school level (Shallcross, 2015:9).

The aim of the flower model is to develop subject expertise and leadership in an increasing number of schools. It is informed by the University of Manchester's Trajectory of Professional Development framework (Bianchi, 2016a). The Trajectory of Professional Development (TOPD) model for CPD (Figure 2.2), developed by Bianchi (2016a) intends to broaden and deepen the understanding of the mechanisms that enable teachers to be supported in developing a professional identity in primary science education. The framework builds on Fairman and Mackenzie's (2012) findings that teachers are internally driven to expand professional knowledge and skills, experiment, take risks, collaborate, seek feedback from colleagues and question their own and others' practice.

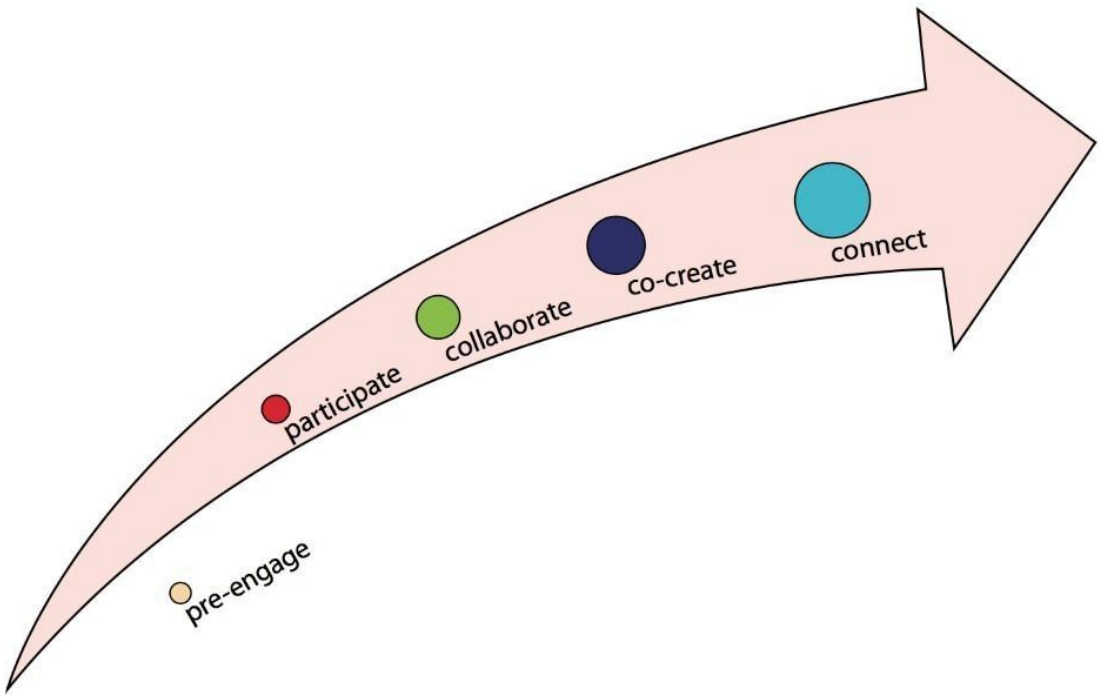


Figure 2.2: Bianchi's (2016a:2) Trajectory of Professional Development (TOPD): a conceptual model for teacher continuous professional development in primary science education

The TOPD model has five stages of development set with an upward directional arrow, representing progress within a particular context. The stages are considered essential steps towards becoming a 'leader' of primary science, progressing from pre-engagement (during which stage individuals are not yet actively developing their professional needs), to participate, to collaboration, to co-creation, and finally connection (at which point individuals are leading and sharing their expertise within new Communities of Practice). In relation to the motivation of this thesis, developing an awareness of how teachers engage with professional development in the first two stages of the trajectory will enable a better consideration of how individuals may engage with the global learning approach in relation to the changing nature of accessing and sharing information. It is clear that the trajectory builds on the standards for teachers' professional development (DfE, 2016), for example: a focus on collaboration and underpinned by evidence and expertise. Furthermore, as argued by Bianchi (2014), it promotes teacher leadership abilities, supporting teachers to shift their philosophies of learning, leading rather than improving classroom pedagogy. I would contend that the trajectory, and the flower model as a whole, infer an end point of professional development. In response, within this study, I will explore how the ongoing nature of professional development may be promoted through a global learning approach in which resources and ideas must be responsive to the dynamic nature of science. Bianchi (2016a) also highlights the need to explore how the educators and collaborators influence the initial and continued motivation and ability of each teacher through the trajectory stages, linking to the concept of developing a CoP, defined above.

The flower model is obviously premised on the promotion of professional collaboration and the building of professional learning communities (communities of practice), underpinned by collegiality, critical reflection on practice, teacher learning and development (inquiry learning) and agency, as Ryan (2016) highlights. Considering these elements will inform the global learning approach to primary science education. The next section looks at The National STEM Impact toolkit, which focuses on individual professional development.

2.5 The National STEM Impact toolkit

The National STEM Learning organisation works with a large proportion of UK teachers, claiming to reach over 80% of primary schools. Interestingly, within my own professional community, schools are often unaware of the opportunity, raising the question of equal access. 'Planning for impact' is embedded in their Impact Toolkit Model (Bryant and Parish, 2015) which uses three evaluation instruments embedded in to CPD: the intended learning outcomes identified prior to the CPD sessions, a personalised action plan identifying action points relevant to their own schools, followed by an impact report, evidencing impact on participants' knowledge and practice, pupils, colleagues and the wider school. It also comprises four phases (as identified in figure 2.3): planning, embedding, evaluating and sustaining, which enable impacts to be sustained.

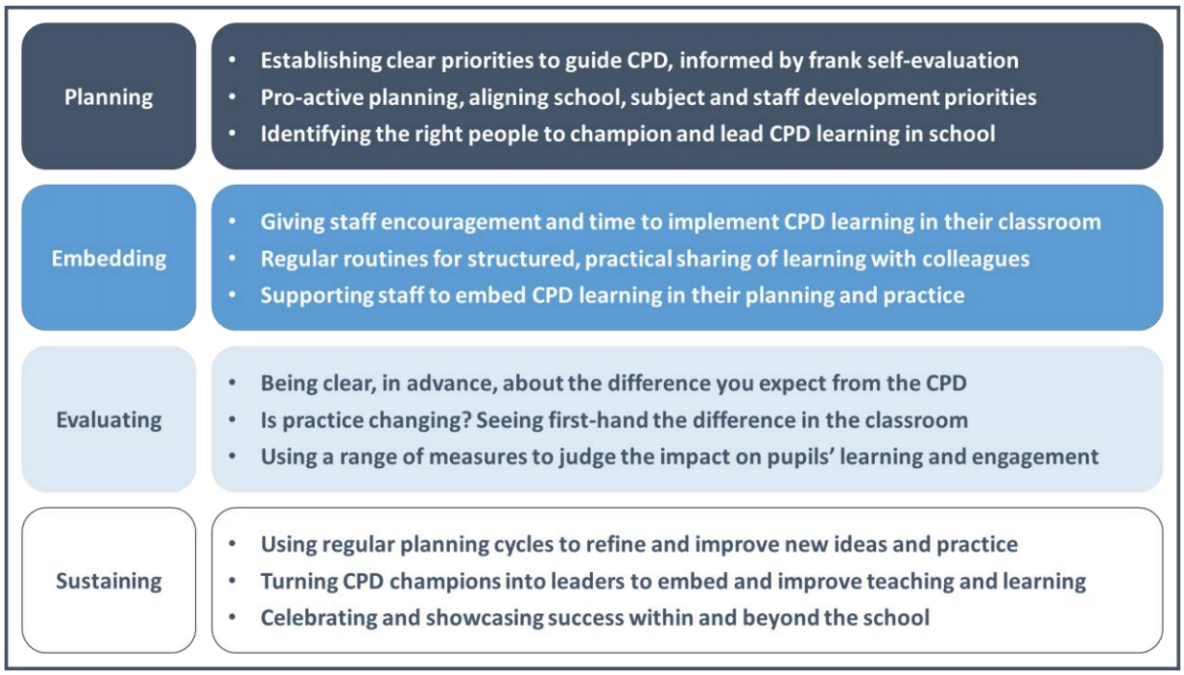


Figure 2.3 The four phases of STEM learning CPD

The toolkit, as Kudenko, Hoyle and Dunn (2015) identified, aids participant learning and simultaneously provides valuable impact feedback. Their research highlights the importance of embedding 'action research' and reflective practices into CPD training, as this positions teachers as 'agents of change' (Fullan, 1993) boosting confidence and motivation to continue with research and innovation. The research also highlights the importance of focusing on outcomes of children and planning for the

collection of impact as important motivational factors. Recent evaluation reports from STEM learning (2020) have highlighted that those schools which have engaged in STEM Learning CPD had a growth in the proportion of students reaching expected standards in KS2 science. One arguable limitation of this model is the prolonged nature of the process which requires an extended engagement rather than bite-sized twilight or afternoon workshops, causing disruption to classroom teaching. As this model requires an intense input of innovative ideas within an external residential course, it becomes challenging to translate these in different school contexts, as the evaluation report by Bryant and Parish (2015) suggests. The impact report highlights that success varies depending on the facilitation of school leadership, suggesting that until schools and science leaders see CPD as an ongoing cycle of planning, embedding, evaluating and refining, the sustainability of a new approach is limited. It is therefore necessary to challenge the current culture and approach to professional development, ensuring longer term commitment from both teachers and their senior leaders.

2.6 The Primary Science Quality Mark

The Primary Science Quality Mark (PSQM) is a programme to develop science teaching and learning in primary schools. As a professional development scheme, it works with over 600 schools each year, mostly in the UK. At the heart of the PSQM process is school self-evaluation: science subject leaders are supported through a year-long process of audit, action planning, implementation and reflection by professional development, online mentoring, and an interactive e-portal. The programme was developed using relevant literature on curriculum development (for example, Stenhouse, 1975) and professional development (for example. Adey, 2004). As a result, the PSQM professional development model aims to change teachers' beliefs and attitudes as well as their teaching practice. The model is based on Adey's suggestion that this cannot occur without addressing both individuals' attitudes to teaching and a whole school's commitment to change. It was seen as critical to the success of the programme that it was collaborative across the whole school staff, sustained over at least a year, and supported with relevant professional expertise through a national network of local hubs and hub leaders (Adey, 2004).

The findings of research conducted by White (2016) highlighted the important role the PSQM has been playing in raising the profile of science in primary schools, especially in a context where there has been a perceived emphasis on literacy and numeracy to the detriment of the other curriculum areas. It identified that the value of science was developed at all levels: the senior leadership team, the staff, the pupils, the parents and the governors. Additionally, the profile of the science leader was enhanced, giving them the recognition with which to lead change.

Several limiting factors were highlighted within the PSQM model (Turner, Warren and Naylor, 2017). Both the cost and the commitment of the senior leadership team were recognised as inhibiting factors. PSQM is labour intensive and requires commitment from the whole school, so the senior leadership team have to identify it as an area of importance. The sustainability of the impact was also highlighted

as a concern, as it very much relies on the science leader to continue using the PSQM framework to promote science across the school. Another challenge is to prevent 'brain drain' as the science leader, as a result of PSQM, often gains experience which enables them to move into a senior leadership role, as I have personally experienced.

2.7 Summarising effective professional development

Priestley (2015) argues that critically engaged teachers can develop the curriculum in constructive ways to improve student outcomes. Considering professional development opportunities to increase teacher agency can, therefore, lead to improved engagement with the development of practice. Shulman's (1987) knowledge bases can be synthesised with an ecological approach to teacher agency created by Priestley (2015) to evaluate the above science-specific professional development models (see Table 2.1, p.25). Priestley's ecological approach to teacher agency includes the importance of previous personal and professional experiences (the iterational aspect) and a teacher's aspirations (the projective aspect). It also considers the ways in which teacher agency can be boosted (the practical-evaluative aspect) which includes three dimensions: individual (teacher beliefs, critical engagement, teaching methodologies and sense-making opportunities, for example, considering the purposes of pedagogical choices), structural (referring to school contexts, incentives, collaboration, power, leadership and processes for enabling innovation), and material (the resources on which the teachers draw upon including the physical environment and practical resources). From an individual level, having an understanding of subject-specific knowledge bases identified by Shulman (especially in relation to the curriculum and pedagogical content) can support teachers as agents of change.

Table 2.1 A summary of science-specific professional development models using the practical-evaluative aspect of Priestley's ecological approach to teacher agency

	Individual	**Structural**	**Material**
PSTT Flower Model	Centres around innovative practice, developing teacher methodologies – recognises the importance of the teacher as a subject expert.	Collaboration and co-creation between teachers and academic collaborators. Funding and a clear process to support innovation.	The development of resources that are disseminated informing national and international policy.
National STEM Impact toolkit	Personalised action plan ensures opportunities for reflection and consideration of impact on own knowledge, pupils, colleagues as well as wider school. The approach focuses on the importance of action research and reflective	Evaluations highlight challenges in translating innovation into the school context and requires the facilitation of effective leadership.	An online support platform and access to resources from workshops supports implementation of innovative practice.

	practice, this critically engaging with teaching methodologies.		
Primary Science Quality Mark	The PSQM aims to change teachers' beliefs and attitudes as well as their teaching practice	The success of the PSQM involves collaboration and commitment across the whole school staff, sustained over at least a year, and supported with relevant professional expertise through a national network of local hubs and hub leaders.	The school needs to fund the process, and ensure time is allocated to ensure that actions can be achieved. The process is supported by a handbook of innovative resources, and the PSQM process involves collaboration with other schools.

As Priestley (2015) acknowledges, the process of teacher agency through professional development is driven by a number of different needs: the individual's personal needs, the needs and culture of the school and society, and the material needs in terms of physical and pedagogical resource accessibility. The aim of this study focuses on the relationship between the individual's personal and professional needs and values and how they are influenced by the introduction of a global learning approach to primary science. The global learning approach aims to support teachers to re-evaluate their understanding of the purpose of primary science, allowing not only children to be active global citizens, using science to live and act responsibly, but will allow them to be empowered as ambassadors, learning and acting alongside those they teach.

2.8 Chapter Summary

This chapter has presented the current climate of subject-specific professional development. The three discussed initiatives sit amongst a range of other primary science professional development opportunities including conferences, learning networks, independent workshops and online courses. However, the three initiatives help to highlight ways in which the individual teacher (micro-level), the school community (meso-level) and wider professional community (macro-level) can be supported.

From a micro level, research highlights the importance of teacher ownership and autonomy of their professional development (the individual construct of the teacher agency model), valuing relevant and usable ideas and strategies from experts that can be adapted and incorporated into their own practice. All initiatives highlighted the importance of student outcomes on the success of professional development. According to Guskey (2013), teachers attempting to change their practice need to observe positive student learning outcomes, to trigger in themselves a change in belief and attitudes. This suggests that if new practice does not result in improved student learning, it will not be

sustained. As highlighted in the STEM impact toolkit, the focus of student impact is a crucial element of individual professional change. It will therefore be important to highlight how the global learning in primary science approach will engage children and promote opportunities to improve and apply their learning.

Johnson, Monk and Swain (2001) also highlight how the context in which an individual teaches affects the pedagogies they adopt (the structural construct). For example, schools with a high proportion of middle-class families who have raised expectations of their children may influence teachers to choose pedagogies focused on exam outcomes. This is acknowledged in Bianchi's Trajectory Of Professional Development model, in which development is dependent on context. This idea warrants consideration for the global learning in science approach, drawing attention to how the pedagogical approach impacts the children, and how this relates to expectations of different stakeholders.

From a meso level, school culture has an influence on primary teachers' professional development. Busher and Harris (1999) identify four parameters affecting a subject's status: structural organisation, status of the subject within the school, social cohesion and collegiality and power. As identified by Joyce and Showers (2002), colleagues had a significant impact on each other in the implementation of new pedagogies, emphasising the importance of collegiality and contexts supportive of risk taking; an aspect identified within the Primary Science Quality Mark model, developing a 'Community of Practice' (Lave and Wenger, 1991). In relation to Bandura (1999:477), a group's 'shared beliefs' and 'collective efficacy' are key components of successful implementation of any new initiative. As articulated by Busher and Harris (1999:307), an important role of the subject leader is to foster collegiality within a group by shaping and establishing a shared vision.' Supporting this, Adey (2004:166) points out that an individual cannot maintain motivation in a new pedagogy 'if they feel isolated'. Developing the successful engagement and implementation of the global learning approach to a science curriculum will, therefore, require the consideration of changes in structural elements such as the status of science in the school, and pathways to support related collaboration and innovation.

Busher and Harris (1991) and Adey (2004) go on to point out that the greatest influence on the implementation of educational innovation is the senior leadership team; recognising the time required and the skill in building the innovation into the school's structure. This, again, is integrated into the PSQM model, requiring the commitment of the senior leadership team, to support development.

At a macro-level, Cuban (1998) proposes that a major barrier to the transformation of classroom teaching is the interrelationship between government policy and schools. For effective professional development outcomes, local and national government support is useful, but not essential. For example, after 2010, in England, as a result of political party changes, the government emphasis on sustainable development and global issues within education policy was reduced (Bourn, 2016). However, there is a growing body of evidence revealing how schools are recognising that global learning is important to their teaching and learning (Bourn, 2016) and further evidence suggesting that

children are more engaged by learning through this approach (Hunt, 2012). The Primary Science Teaching Trust flower model, for example, aims to use evidenced practice to inform policy, which needs to be considered in this study.

A culture of personal targets, competence standards and accountability measures, professional development may become viewed as a product, rather than intrinsically valued professional opportunities (Darling-Hammond, 2017). As a result, if professional development related to global learning in science is not linked to government ideologies and the related curriculum specifications, teaching and learning and inspection frameworks, it may arguably be not a valuable commodity to teachers. Darling-Hammond, 2017 highlights that professional development must involve expert support, collaboration and needs to be related to the curriculum context in order to support teachers as agents of change.

The wider professional community (universities, charities, subject associations, NGOs and private companies) also has an influence on professional development, for example through research-informed practice or funding. Organisations such as the Wellcome Trust and ASE are involved in government lobbying, proposing teacher standards and helping to interpret the curriculum. PSTT's flower model, for example, supports evidence-based innovation and online resources to support teachers. All these funding organisations have a vision of what science education should look like (as highlighted in Chapter one), which subsequently influences professional development.

At an Educational Doctorate level, in my role as a university staff member, I am also aware of how research findings directly influence professional development design, the integral PCK, implementation and evaluation. For example, the University of Bath's TAPS assessment innovation has been endorsed by both PSTT and PSQM and influences primary science assessment nationally. We cannot underestimate the influence and importance of government and external bodies, but any policy, research findings and programme development programme need to be translated and enacted by skilled, knowledgeable and confident teachers who are empowered as 'agents of change'.

CHAPTER THREE LITERATURE REVIEW: TEACHER MOTIVATION, TEACHER BELIEF SYSTEMS AND AGENTS OF CHANGE

3.1 Introduction

Literature reviewed in Chapter two which focuses on the dimensions of subject-specific professional development indicates the importance of teacher beliefs and attitudes in the implementation of change. It is, therefore, necessary to explore the relationship between primary teachers' attitudes, beliefs and the implementation of a global learning pedagogical approach towards primary science education. At a micro-level, the focus of the research will be on the teacher, their professional autonomy and a need to understand their motivations in engaging with and developing their science curriculum with a global learning dimension. A larger aim is to consider why some teachers engage in this more than others. At a meso and macro level, models and ideas to support the development of a teacher's understanding of their roles as agents of change will therefore be explored. The study will consider how the introduction to a global learning pedagogical approach may relate to, or challenge, a practitioner's beliefs about science education. The thesis will explore how a global learning pedagogical approach to primary science may support a greater investment in the subject, beyond the delivery of the National Curriculum framework.

Subsequently, this chapter aims to explore the research literature surrounding teacher beliefs, attitudes, teacher professional autonomy and teachers as agents of change. As a result, this section of the literature review will aim to identify how teachers can be supported to view science learning through a critical lens in order to deliver a primary science curriculum fit for global citizens, considering whether it has a wider purpose, and their role as agents of change and subsequent development of primary science teaching and learning.

3.2 Beliefs and attitudes towards global learning

This thesis focuses on a global learning approach to primary science teaching and learning. Importantly, for the uniqueness of this thesis, no research was found with specific relation to primary teachers' beliefs about global learning in science education. However, three areas of literature were considered relevant for this chapter, potentially informing teachers' use of global learning in science. These fields include beliefs around global learning as a pedagogical approach, beliefs around the place of education for sustainable development and sustainable development goals in the primary curriculum and beliefs relating to science epistemologies and how children learn in science.

3.2.1 Global learning as a pedagogical approach

Global learning is concerned with helping children to understand themselves and others in relation to place, time, belief, identity and culture (Scoffham, 2018), inviting them to participate in their global

society as active and engaged citizens (Eaude, 2017). It focuses on the teaching and learning processes that involve enquiry, participation, experiential and active learning, dialogue and discussion and reflection and action (Bourn, Hunt and Bamber, 2017). Hunt (2012) summarises the approach by advocating that it should promote children's engagement, empowerment and sense of agency with regard to their present and future lives as global citizens. Central to the global learning approach is a consideration of the importance of pedagogy: moving towards pedagogy which not only includes subject knowledge and skills but considering their relevance within the local and wider global context, as highlighted by Bourn (2014). This is influenced by the concept of critical pedagogy (Giroux, 2011) which emphasises the importance of relating learning to contexts, students and communities in which they are conducted.

When considering this understanding in relation to science learning, a global learning approach can therefore support children to use enquiry, participation, experiential and active learning to support the development of scientific knowledge and skills that they can use in relation to their own lives and as active global citizens. However, children need to be supported to do this. It could, therefore, be argued that the science curriculum has the potential to support global citizens, if a global learning approach were to be supported explicitly. For example, when children learn about properties of materials, a more direct focus could be placed on responsible consumption of natural resources, through critical and creative thinking. As will be explored further in this chapter, this may require a shift in a teacher's epistemological perspective. As Scoffham (2018) highlights, global learning is an evolving and contested area of the curriculum with many challenges and opportunities. Despite the risk of being misinterpreted by government agendas, Scoffham (2018) emphasises its potential to act as a catalyst for curriculum change, underpinned by the wider purpose of education. Being aware that global learning is an emerging area of study with evolving terminology, it will be essential for teachers to avoid misunderstanding and confusion.

The value of global learning to teachers, educators and their institutions has been well-documented, although in a very fragmented way through papers and reports (Bourn, 2016). Practical support to formal (as well as informal) educators in the use of global learning approaches and themes is disjointed and unevenly distributed through England. Although web-based access to resources, such as that offered by the Global Dimension (2020) and Practical Action (2020) website are valuable, any resource platform must be supported by a theoretical underpinning developed during in-service and pre-service training of educators (Alexander, 2004; cited in Husbands and Pearse, 2012). Teacher educators, therefore, have the challenge of supporting practitioners to consider, rethink and enact critical pedagogy, underpinning a global learning approach to science, which relates to the rapidly changing context in which our learners live.

The Global Learning Programme (GLP), a government funded programme which ran from 2013 to 2018, was an initiative aimed at supporting schools to deliver effective global learning approaches throughout the curriculum, engaging more than 7800 schools. Research evaluating global learning

outcomes concluded that ‘changes in knowledge, attitudes and actions are at the heart of global learning’ (Bamber, Bullivant, and Stead, 2013:7). Ofsted (2015) identified the contribution of the approach to the enjoyment of learning, reinforcing their curriculum knowledge and understanding. Research findings have also highlighted the positive impact on confidence of learners, improved personal and social development of learners, a deeper understanding of citizenship, improved attainment and enriched school improvement (British Council, 2020).

Despite the positive impact of global learning on curriculum knowledge, understanding, skills, value and engagement, as highlighted positively in Ofsted inspection reports (Hunt, 2016), the GLP is no longer funded by the government and has been replaced by an initiative called ‘Connecting Classrooms’ (British Council, 2020). ‘Connecting Classrooms’ has a similar aim to GLP, supporting educators to equip children with the knowledge, skills and attitudes to act more thoughtfully, ethically and responsibly as citizens and contributors to society through professional development and developing partnerships with classrooms internationally. However, the initiative requires motivation from each school and individual teacher to apply for funding and find an international partner school to work with. As a result, initiatives that are policy (and funding) driven dominate and resume greater value, which can influence teachers’ attitudes and values towards such pedagogical approaches and initiatives (Nelson, Spence-Thomas and Taylor 2015).

Further to this, unsurprisingly, given its evolving nature, many teachers have a distorted understanding of global learning in relation to charity engagement (Scoffham, 2018). The idea of global learning being ’just about poor people who are helpless and in need of aid and charity’ (Bourn, 2014:33) must therefore be challenged. Research also identifies that teachers steer away from incorporating global learning in fear of reinforcing a particular view or opening up debate about controversial issues (Bourn, 2014:26). As Blackmore (2016) warns, the misconception that teaching through global learning is about transmitting information about controversial issues and dilemmas needs to be challenged. Instead, teachers should be supported to understand that it is about encouraging children to take a critical position and challenge assumptions and beliefs. Although it is argued that teachers need to be well-informed about global issues and the pedagogical skills to teach them (Scoffham, 2018), Balsiger et al., (2017) argue that the most important aspect of using a global learning approach is about transformative learning and the wider purpose of a subject area. This is central to the focus of this thesis.

3.3 Teacher beliefs and attitudes

Decision-making about teaching approaches is significantly influenced by beliefs and attitudes about teaching and learning (Mansour, 2009; Fives and Buehl, 2016). Van Driel et al., (2007) suggest that views about teaching and learning are well-established before a teacher enters the profession. The beliefs that allow us to define, understand and interpret our world and ourselves (Levitt, 2002) directly affect teachers’ practice in the classroom, including how they approach the teaching of each subject

area. For Alexander (2004: 7-8), pedagogy is not just the 'act of teaching' but also the 'ideas, values and evidence about children, teaching, learning, curriculum and culture'.

A teacher's epistemology of science can be defined as their understanding of the nature of knowledge and knowing in science (Lederman, 2007). As King, Shumow and Lietz, (2001) agree, the beliefs of primary science teachers about teaching and learning are intertwined with their beliefs about epistemology of science. Samual (2015) goes further to indicate that teachers' epistemological beliefs are correlated with their pedagogical practices. In agreement with Fives and Buehl (2016), it follows that through understanding the relationship between teachers' epistemological beliefs and their practice, a more successful and sustainable implementation of the global learning approach to primary science may proceed.

The previous chapter outlined literature identifying teacher engagement with professional development opportunities (Wellcome, 2018). Considering literature specific to the relationship between primary science teacher's beliefs and attitudes and their engagement with professional development and changes in pedagogical practice will further inform this study. Literature related to beliefs regarding science learning and teaching, epistemology of science and global learning (as a pedagogical approach) will, therefore, be explored.

3.4 Exploring primary teachers' professional beliefs

Beliefs can be defined as individual constructs based on personal judgement and evaluation which are critical when understanding a teacher's practice (Luft and Roehig, 2007: 47). Supporting this, Pajares (1992) goes on to highlight that beliefs can be understood as personal entities that individuals are committed to. Woolfolk Hoy et al., (2006) predicts that teachers' professional beliefs are products of their experiences as learners (which may, as a result of high-stake tests in primary and secondary school, have been assessment driven), thus influencing their interpretation of new teaching approaches. As Wallace (2014) highlights, science teacher beliefs play an important role in informing pedagogical decisions. Lumpe (2012) suggests that when science teachers' beliefs resonate with new strategies, they are more likely to be implemented. Contrastingly, Guskey (2002) stated that significant change in teachers' beliefs and attitudes can only take place after changes in children's learning are evidenced.

Exploring how professional development can influence and change teacher beliefs in relation to primary science is an important aspect of this thesis. Glackin (2016) considers planned and unplanned professional development as important in facilitating changes in teachers' beliefs. As a result, understanding the relationship between teacher beliefs and engagement with global learning in primary science professional development workshops as well as unplanned professional learning (for example. practitioner independent planning, research and resource creation) may be central in facilitating

changes in teachers' beliefs about science education and subsequent integration of the global learning pedagogical approach.

3.4.1 Teachers' beliefs and attitudes towards teaching and learning primary science

The concept of 'transformative learning' was initially theorised by Mezirow (1991), with a focus on higher education, who saw an individual's transformative learning as a paradigm shift (through critical reflection, metacognitive reasoning and questioning of assumptions and beliefs). As Maiese (2017) articulates, transformative learning, rather than being the acquisition of new knowledge and information, focuses on personal transformation, altering perspectives, interpretations and responses. Transformative learning is underpinned by social constructivism, with the view of learning as a social and cultural process through which multiple interpretations of differing perspectives lead to a shared sense of reality (Freire, 2000). As well as the constructivist view of the importance of critical reflective thought through problem-solving (Freire, 2000), social constructivism concentrates on the importance of social interactions to influence thought and action of the individual (Vygotsky, 1986). Essential to Mezirow's learning theory and influenced by Vygotsky's (1986) theory of social constructivism and Dewey's philosophy, learning experiences should open the door to further experience. In line with the global learning approach, learning opportunities should support children to engage with their world for further, enriched experiences.

Understanding how teachers' beliefs and attitudes relate to their understanding of how children learn is an important aspect of any successful professional development programme (Nelson, Spence-Thomas and Taylor 2015) because it enables teachers to make links between how they teach and how children learn. The subsequent chapter will outline the framework underpinning the development and undertaking of the global learning in primary science professional development, informed by this principle. The global learning approach to primary science approach will be underpinned by a transformative paradigm (outlined below), as described by Taylor (2015) and Bourn, Hunt, Blum and Lawson (2016), where the related pedagogical approach incorporates critical thinking and personal and social application of new scientific knowledge. Subsequently, a paradigm shift in teacher beliefs about science may be required.

It can be considered that teachers' beliefs about science education operate on a continuum of pedagogical theories. Larrivee (2000:293) argues that without professional development intervention, teacher beliefs are often 'self-generated and unchallenged'. Goodrum (2006) suggests that teachers often enter the education system with traditional views about science learning, often as a result of their own didactic science learning experiences. As Hodson (2017) argues, science teaching and learning is often preoccupied with preparing children for later study of science, towards secondary, then towards university and in subsequent employment in science-based careers. Science teaching and learning in England, guided by the programmes of study (DfE, 2013), are dominated by the approach in which the development of conceptual knowledge is conducted through enquiry and application of science process

skills (Girod, 2010). This view, reflecting Piagetian constructivism, values the importance of obtaining a body of conceptual knowledge through 'working scientifically' (DfE, 2013), a term coined in the National Curriculum to include enquiry approaches and process skills. It is argued that this perspective is the default model for science teaching and learning, certainly in England (Girod, 2010).

This constructivist approach, as argued by Pugh et al., (2010), may overlook or misrepresent aspects of science and science learning. Dewey (1933) argues that for any learning experience to be complete, it must be transformative, generating a growing exploration of the everyday world. Hodson (2017), for example, argues that a shift in approach is required towards preparing young people as informed, critically aware, socially responsible and globally active citizens. Pugh and Girod (2007:10), for example, suggest that teachers are more likely to ask questions like, 'do students understand the concepts correctly?' rather than 'do concepts make a difference in the students' every day, out-of-school lives?' It could, therefore, be argued that a global learning pedagogical approach to primary science may be powerful and helpful in challenging teacher beliefs about the nature of science and its purpose beyond preparing young people for science-related careers. Considering how to analyse and challenge personal beliefs in relation to the global learning approach will be an important aspect of the study in order to promote a paradigm shift, as Brownlee (2003) suggests.

Current views support a constructivist approach informing the enquiry approach to the delivery of the science curriculum, as discussed by McCrory (2018). This study goes further to suggest that science learning should enable children (and teachers) to consider the wider (global) implications: a transformative view of science learning. Pugh and Girod (2007) summarise this transformative view of learning into three pedagogical dimensions: shaping ordinary content into important and powerful ways of seeing the world; modelling the power of how ideas can transform our lives; and supporting students to apply their learning to their personal lives.

Rogriguez and Kitchen's (2004:5) work articulates the challenges related to teachers' ideological and pedagogical change, articulating the importance of awareness, confidence, knowledge and skills to implement a more culturally responsive and socially relevant curriculum. They go on to identify pedagogical change as equally difficult to change, often due to lack of confidence in teaching science (content knowledge and curriculum knowledge) and / or knowledge and skills required to move away from familiar approaches. Walton-Fisette, Philpot and Philips (2018) advocate that professional learning should support opportunities for practitioners to reflect critically, enabling them to identify and reconstruct their beliefs and values that underpin their teaching. Ovens (2017), however, recognises that transformative pedagogy can also be enabled or constrained by factors including policy, environments, institutional constraints and even approaches advocated in initial teacher education.

This study argues that a global learning approach to primary science is underpinned by a transformative paradigm, which includes an appreciation of the importance of developing scientific conceptual understanding to see the world from different perspectives, to make informed choices in daily life, and

to use science knowledge to act responsibly as global citizens. It could be argued, therefore, that teachers could be empowered as agents of change (Pritchard, 2017) and challenging beliefs around their theoretical frameworks may fuel this sense of agency. When delivering global learning in primary science professional development, underpinned by transformative science pedagogy, there must also be an awareness of potential 'resistance' to change outlined above. This study will aim to consider the factors which may inhibit a new positioning, through raising awareness, confidence and/ or knowledge and skills to implement a more culturally responsive and globally relevant curriculum.

3.4.2 Teachers' beliefs: epistemology of science

As described above, epistemology relates to the nature of knowledge and reasoning behind belief (Muis, 2004: 317). Amongst the range of beliefs, it is argued that teachers' epistemic beliefs are central to how or whether they make changes in pedagogical practice (Schommer-Aikins and Hutter, 2002). In other words, teachers' understanding of science knowledge is related to how they view their teaching. Lin and Chan (2018) argue that rather than seeing science as a way of knowing, teachers often consider it as a body of knowledge. As a result, scientific enquiry in school science can be seen as a means of acquiring a set of skills, such as making observations or collecting data to teach a pre-defined body of knowledge.

In relation to science learning, developing teachers' beliefs about knowledge, not as a body of knowledge to disseminate, but as provisional and continually changing, has the potential to allow them to acknowledge the importance of a global learning approach, in which learning is viewed as a transformational journey (Mezirow, 1997). Challenging teachers to consider progressive pedagogies (Webber, 2016), which are underpinned by an understanding of learning occurring when children are actively engaged in the process of constructing meaning and knowledge (Sherrington, 2017), will require them to reconsider their epistemological beliefs about the subject (as argued by Stears, 2009; Shapiro, 2011). An integration of a global learning approach may involve thinking differently and encouraging student-centred learning in which learners are able to see their science knowledge acquisition and discoveries in relation to their own context (Blackmore, 2016; Sherrington, 2017). The consideration towards this shift requires teachers not only to reflect on their beliefs about the nature of science, but a greater consideration of how they evidence the effectiveness of a change in approach.

Whilst there is a substantial body of research related to how teachers' epistemic beliefs mediate their science teaching practices (Tarmo and Bevins, 2016), little is known about how teachers' epistemic beliefs may relate to their teaching practices for global learning. Considering how to support teachers to reflect on their beliefs about the wider purpose of science will, therefore be aimed at promoting pedagogies in line with a global learning approach with the objective of enabling learners to consider science in relation to themselves and the world around them.

3.4.3 Teacher beliefs and attitudes towards Education for Sustainable Development

The Sustainable Development Goals decided by the United Nations include SDG target 4.7 which centres on learners gaining the necessary knowledge and skills to promote sustainable development (UNESCO, 2015). UNESCO (2002) defines Education for Sustainable Development (ESD) as a new vision of education which empowers learners to assume responsibility for creating and enjoying a sustainable future. Bourn (2016) discussed in his research report the problematic nature of terms associated with global learning and sustainability, endeavouring to define terms such as 'global citizenship', 'education for sustainable development' and 'development education'. As referred to in the introduction of the thesis, operationalising education to promote sustainable development, global learning can promote children's engagement, empowerment and sense of agency with regard to their present and future lives as global citizens.

Whilst global learning incorporates the importance of critically reflecting on global interdependence and the learners' own values and attitudes (Bourn, 2016), there is an overlap with ESD in its promotion of sustainable development and improved capacity for people to address environment and development issues. ESD is an area in which trainee teachers and in-service teachers lack the confidence and preparedness to conceptualise and practice (Green, 2015). As a result, Green suggests that this is one of the key barriers to its implementation. This will be equally true for global learning. Further to this, since 2010, the change in government in England has resulted in a reduced emphasis on sustainable development. As UNESCO (2013) reveals, this has increased uncertainties amongst educational establishments and practitioners about how much emphasis should be placed on sustainability within teaching and learning.

Bamber et al., (2016) go on to explain that as a result of England's market-driven, performance-focused and bureaucratic education environment, teachers and schools focus on short-term observable outcomes rather than longer term changes in behaviour, attitude and practice. Teachers, therefore, prioritise subjects like English and mathematics, as well as aspects of science for which they are accountable for measurable progress instead of aspects of ESD and global learning in which impact is often immeasurable. This is significant when considering why schools and teachers choose tension to engage with different pedagogical approaches and initiatives.

ESD, along with global learning, is underpinned by transformative pedagogies (Evans et al., 2016), challenging individuals' actions and perspectives towards the world around them. Although there is limited research, some studies have highlighted the lack of confidence related to teaching ESD due to insufficient knowledge, training and skills (Bullivant, 2017). However, a recent research study working with pre-service primary teachers (Evans, Engel and Woods, 2016) highlighted that an increased confidence and motivation to teach ESD was attributed to an increased knowledge and understanding of sustainability issues. Subsequently, support around the development of knowledge and understanding around global issues will be an important aspect of the global learning in primary science

workshops, to ensure both motivation and confidence to incorporate the integral pedagogical approaches.

Whilst sustainability is recognised as an emerging purpose of education (Hopkins, 2013; Mogren, 2019), it is yet to make any significant impact on the approach to teaching and learning. For example, in relation to the United Nation's Sustainable Development Goal 4.7, which highlights the importance of all learners acquiring the knowledge and skills to promote sustainable development, research has highlighted that whilst there is evidence of some good practice, pressures of achieving attainment targets dominates teachers' approaches (Bourn, 2017). Whilst research highlights that both trainee and in-service teachers convey a positive commitment towards teaching and learning related to sustainable development (for example, Summers, 2014), findings also suggest that considerable input is required for teachers to effectively engage with ESD. Further to this, as discussed by Bamber et al (2016) wider government support is necessary in order to ensure consistency in related pedagogy. Again, considering the influence of wider educational agendas is important in relation to teacher and school motivation and engagement.

3.5 Primary teachers as agents of change

The National Curriculum in England dictates the programmes of study year by year, whilst schools and teachers are responsible for interpreting and developing the content (Wellcome, 2019). As Alexander (2004) and Carse (2015) argue, there is a dissonance between centrally driven curriculum reform and the encouragement of teachers to interpret and deliver curriculum content using their creative energies and professional beliefs. Davies et al (2017) agrees that there is a tension between this freedom and concerns about the hidden expectations for external accountability. An important aspect of this study, therefore, is to explore ways to support teachers in developing a greater change capacity, developing confidence in their approach to primary science. Further to this, a dimension of this study will involve considering how to support teachers to critically challenge their own beliefs of the purpose of science education which is integral to a global learning pedagogical approach.

Educational research shares a number of definitions of agency. Biesta, Priestley and Robinson (2015) refer to agency as something that people achieve, rather than something that people have. This definition is supported by Moore (2008) who conveys that agency is about having the power to act purposefully and reflectively and to having a conscious role in bringing about social change. Drawing these two definitions together, I would agree with Zeichner (2019) who concludes that teacher agency should be the autonomous and democratic role of education. The following section will explore the role of teachers as agents as change. In relation to this research focus, the aim is to consider how individuals and groups can reflect, act, modify and give significance to the teaching of science in purposeful ways.

3.5.1 Defining teachers as agents of change

Etalapelto and Vahasantanen (2013) define professional agency as the ability of professionals (both individuals and communities) to influence, make choices and have perspectives on their work and professional identities. As Goodson (2003:76) emphasises, a teachers' personality, beliefs, ventures and ownership of their work can influence the improvement of practice and implementation of curriculum change. Teachers' awareness of their professional selves can then influence how they practice agency at work (Eteläpelto and Vähäsantanen, 2013). Teachers' professional agency and the social context in which they work can therefore be seen as being mutually powerful and highly interdependent (Eteläpelto and Vähäsantanen, 2013; Lasky, 2005; Van Oers, 2014).

As outlined by Priestley (2019), the term 'curriculum' is largely contested. Whilst it can be broadly defined as an umbrella term for all learning experiences of young people in school (Priestley, 2019). Tyler (1969) emphasises the importance of asking about the underpinning purposes, how and what experiences will achieve those purposes, and their organisation, when developing a curriculum. According to Kerr's (1968:16) definition of the curriculum, 'all the learning which is planned or guided by the school', it suggests that experts define the objectives and select the content of a curriculum. Stenhouse (1975), in contrast, argues that the teacher plays a crucial role in translating the curriculum at a classroom level, describing it like a recipe in cookery. Heijden (2015) agrees that teachers need to be the real change agents in order to ensure that curriculum frameworks are made relevant to their students. As a result, this study will consider the significance of both the intended curriculum (aims, standards, benchmarks, outcomes, content, strategies, materials and assessment guidelines) and enacted curriculum (the actual use of the intended curriculum in classroom practice) (Porter and Smithson, 2001), considering teacher beliefs, attitudes, experiences and contexts when interpreting and delivering the science curriculum. Subsequently, it is important for teachers to learn and change from 'inside' (internal drive to reflect and make sense of things) and 'outside' (meeting external demands), both individually and in collaboration with others in their schools (Fullan, 1993, Hargreaves and Fullan, 2020; Hattie, 2012) to effect change in practice.

Vähäsantanen (2013) distinguishes three complementary perspectives of professional agency, namely in terms of: influencing one's own work; making decisions and choices about one's own involvement in educational reform; and negotiating and influencing one's own professional identity. These are all meaningful features of any professional development, aiming to support teachers to act as agents of change within the context of school and wider educational change. Eteläpelto and Vähäsantanen (2013) provide an explanation of professional agency as practices by which teachers develop and actively negotiate their identity position at work, how they develop themselves professionally (lifelong learning), and the way they enact their agency at work. Investigating teachers' professional agency from this perspective is significant, as the way teachers reflect, act, and develop, through and during their work, is powered and resourced (or constrained) by the sociocultural context in which they work (Lasky, 2005; Eteläpelto and Vähäsantanen, 2013; Van Oers, 2014).

3.5.1.1 Supporting Teachers as agents of change

Fullan (1993: 2) proposes that educators need strategies to engage in constructive change. He suggests that essential tools for supporting teachers to build greater change capacity are 'moral purpose' (wanting to make a difference) and 'informed professional judgement' (the development of knowledge and understanding of the curriculum and pedagogical innovation). Exploring teachers' belief about the purpose of science education and how they are enabled to act as change agents in the delivery of the science curriculum, as supported by Stenhouse (1975), could be pivotal to their sustained and intrinsic motivation in the subject's development within each classroom, an important point for mid to late career teachers.

Fullan (1993) also recognises that successful change to the way a subject is taught (whether this is policy driven or individual driven) requires both top down (government and local authority) and bottom up (teacher and school) support. Drawing on Archer's (2012) work on reflexivity, a teacher's professional values and beliefs can influence their interpretation of a curriculum. However, Hawkes (2018) suggests that successful teacher agency should be underpinned by school-wide values, which can provide a common language through which to enact sustainable curriculum development. This is supported by Priestley's (2015) approach to teacher agency which considers the important interplay of teachers' contexts and their individual capacity (their beliefs, experiences and aspirations).

3.5.2 Agents of changes as ITE students, teachers and primary science consultants

Within the context of this study, a key dimension is the exploration of ways in which curriculum change can be motivated. Firstly, this study will aim to identify whether teachers (and other influential stakeholders) believe that science education should be underpinned by a global learning pedagogical approach. Secondly, as literature has identified, it needs to consider how inhibited factors can be tackled, in order to support teachers in the delivery of a science education underpinned by the subject's wider role in our global society. Factors from all levels including teachers' perceptions of, and confidence in, teaching science, the time and value dedicated to science at a school level, accountability, provision of science education within ITE and CPD, and resources (Wellcome Trust, 2018).

Literature highlights that effective professional learning and ITE provision can lead to sustained curriculum change (Cordingley, Higgins and Greany, 2015; Allen and Sims, 2018). It is evident that various factors contribute to teacher agency, enabling teachers, trainee teachers and advisors to view change as a process they are part of, rather than something that is imposed upon them. As the previous chapter suggests, professional development should be long term and sustained, it should involve time and space for teachers to become immersed in the process, reflecting on and improving their practice through continued learning, and it should generate opportunities for collaborative and professional dialogue. From the very beginning of teachers' professional journeys, the incorporation of community networks in their professional learning is required to enrich and develop their personal and professional

identities and values. This indicates that a global learning approach to primary science should involve establishing core values, developing awareness of global issues, appropriate knowledge and skills, as well as a grounding of epistemologies and related pedagogical strategies. Subsequently, implementation may, therefore, be dependent on the development of appropriate understandings of teacher educators and their involvement in the Community of Practice.

3.6 Chapter summary

This chapter has explored the significance of teachers' beliefs and attitudes surrounding science, science learning and global learning. It is argued that teacher beliefs and attitudes towards science teaching and learning influence pedagogical decisions. This study argues that global learning in science as a pedagogical approach has the ability to challenge teacher beliefs and attitudes which will in turn alter their pedagogical decisions.

Literature examined within this chapter has focused on teacher beliefs related to teaching of the epistemology of science and beliefs about global learning and sustainable development. Subsequent empirical research for this dissertation will explore how the global learning in science workshops can aid teachers in the identification of their current beliefs around science teaching and learning, epistemology and global learning, in order to enable them to implement global learning as a pedagogical approach towards primary science teaching and learning.

Although no literature was found exploring the relationship between global learning and primary science learning and teaching beliefs, the research explored considers beliefs as potentially influential on teachers' practices around global learning in the primary science curriculum and the subsequent pupil engagement. This review of literature has given rise to the research questions and aims outlined in Chapter one. It is clear that current literature does not consider the relationship between beliefs towards science, global learning and agency. In relation to Stenhouse (1975) who articulates the crucial role of teachers in translating curriculum into practice, along with the importance of exploring professional development models (as outlined in Chapter 2), considering how a global learning approach can support teachers as agents of change, will contribute to literature in this field. Chapter four will outline the pedagogical framework, structures and strategies of this thesis's professional development approach: global learning in primary science.

CHAPTER FOUR CONCEPTUAL FRAMEWORK: A GLOBAL LEARNING APPROACH TO PRIMARY SCIENCE

4.1 Introduction

In Chapter two, the main principles of effective primary science professional development programmes were explored, including informing a clear framework for the global learning in primary science professional development, a theoretical foundation and a transformative approach to professional learning. Chapter 3 reviewed literature related to teacher beliefs and teachers as agents of change, outlining the significance of these constructs on the success of professional development in primary science education. This chapter describes the conceptual framework for this study – 'Global learning in primary science' – drawing on the underpinning theoretical base.

4.2 Successful programmes with the aim of developing teachers' pedagogical practices related to global learning

Chapter 1 recognised that in order to implement successful professional development with a global learning focus, a greater understanding of its underpinning theoretical framework is essential. Alongside the science-specific models of professional development explored in Chapter 2, considering recent initiatives with the aim of developing teachers' pedagogical practices in global learning was also imperative to ensure that strengths are harnessed, and recommendations are taken into account.

4.2.1 Senior leadership support

Appendix I, on page 166, of the appendices, provides an analysis of global learning initiatives across the world to identify both strengths and recommendations. Similar to the science-specific models of professional development, it is clear from the initiatives outlined in the table that a key facilitator of global learning is support from the Senior Leadership Team. As Adey's (2004) model of professional development asserts, support from an SLT enables increased timetable capacity, opportunities for collaboration and preparation, a shared discourse and expectation around an approach, such as global learning, within planning and delivery of the curriculum. The analysis also shows that despite the challenges of teachers' demands, timetable restrictions (specifically, the prioritisation of English and mathematics), and lack of time to work together, having a lead teacher coordinating global learning enabled progression, evaluation and a sense of accountability. Whilst primary schools usually have a science lead, having a global learning champion to guide and support the integration of a global learning approach is less common. As a result, aiming for the science lead to become an expert in global learning related pedagogy may allow for a shared understanding of global learning and its integration in the science curriculum, embedded within the subject's development. Within this research study, opportunities for the leaders of science to develop expertise in global learning will be explored.

4.2.2 Embedding a global learning approach into planning

In relation to curriculum and learning, the analysis also highlights the importance of well-defined planning of global learning into schemes of work and lesson plans, with specific outcomes. Successful initiatives advocate participatory, active and transformative pedagogy (Education Scotland, 2016b, Rosenkränzer et al., 2017) with an emphasis on enquiry and the development of critical thinking, including developing pupils' questioning, discussion and information skills as well as critically reflective knowledge, encouraging creative thinking with the ability to apply learning to new contexts. Supporting practitioners to choose pedagogical strategies therefore requires a consideration of how they align both with global learning and scientific enquiry. Through the review of global initiatives (appendix I) and my own experience of primary science pedagogy, a range of strategies were shared through the workshops, highlighting how they are coherent with a global learning approach to primary science. The use of Philosophy for Children (Lipman, 2008) strategies, for example, promote critical and caring thinking, as highlighted by Bourn (2016) and can enable children to consider the nature and consequences of science. The Open Spaces for Dialogue and Enquiry (OSDE) methodology, developed by Andreotti (2006) supports critical engagement with complex local and global issues. Based on Friere's critical pedagogy, it provides a safe space for children to think independently and make responsible and conscious choices about their own lives and how they affect others. Using an OSDE approach, informed thinking through science enquiry can be evaluated in relation to new questions, different approaches and application of scientific evidence. These strategies, summarised with global learning in primary science examples, are illustrated in greater depth in appendix VIII, page 183.

4.2.3 Sustained, ongoing professional development

As well as the consideration of planning and pedagogy related to global learning, it has become increasingly evident that successful initiatives involve ongoing support for teacher professional development. The use of Sustainable Development Goals (SDGs) to guide the development of knowledge, understanding and skills related to global issues is recommended (Johnston, 2018). However, demonstrations and coaching were identified as effective to support teacher confidence in teaching global issues (Schleicher, 2012). Whilst Young (2008) underlines the importance of 'powerful knowledge' which will always remain fundamental in any education system, Jonasson (2016) argues for the sustained and effective development of new knowledge and competencies in a world of rapid developments of knowledge, skills and societal and technological environment. Jonasson (2016) further argues that sustained development of teachers' subject knowledge within a changing world to ensure global learning requires space and support to integrate new ideas into the curriculum. There is, therefore, an opportunity to use global learning as a vehicle to ensure that science content knowledge and PCK is reflective of the immense changes that are happening in our local and global landscape, motivating a framework for sustained, on-going professional development.

4.2.4 A guiding framework / planning tool

Additional to the points raised concerning professional development above, a framework through which a global learning approach can be embedded into teaching and learning must be considered. Schools and teachers must have the space to integrate current and future changes through the use of a range of teaching strategies, as well as the mechanisms that allow for this. Hunt (2015) reported the benefits of a whole school approach through which global learning principles are integrated through policy and curriculum frameworks. When considering a subject-specific approach, it is therefore important to explore how best to support practitioners to integrate the PCK (pedagogy and resources) in line with the global learning approach, with an awareness of how professional development is translated into practice. As a result, within the context of primary science, it is important to consider how to use ITE and CPD to facilitate creative and collaborative lesson planning which incorporates such pedagogy and global issues.

4.2.5 A subject-specific approach to global learning

The analysis of current initiatives also highlights the need for values development and critical thinking about global learning to be embedded in subject teaching (Cotton, 2018). An impact report conducted by the Global Learning Programme Ireland (2017) suggests that global learning and critical thinking within a subject can strengthen understanding and reasoning. Despite the acknowledgement of the benefits of a 'whole-school' approach to global learning, this study aims to make best use of teachers' expertise and curriculum knowledge within the area of science, ensuring that systematic planning allows for a more coordinated approach to global learning. As Tillmans (2017) asserts, existing frames of mind (ways of thinking and planning) need to be challenged in order to transform an approach to learning. Consequently, helping teachers to develop their own understanding of global issues and consider how it links to the science curriculum they teach may support them to change their practice. However, the systems through which this can be done need to be explored.

4.2.6 From a macro level – policy guidance

Previous impact reports (Bourn, 2016) highlight the importance of government backing and sustained support of a global learning approach, ensuring that its benefits are not overridden by new initiative and accountability priorities, which is a real challenge for UK schools. One of the macro aims of this study, therefore, will be to inform policy makers of clear guidance on how global learning should be implemented through the curriculum, with advice on its pedagogical and social importance within the area of science (highlighting the benefits within teaching and learning). This will allow global learning to become perennial and not merely transitional with other initiatives. This study will aim to provide evidence supporting this. My position within ITE and in-service training of teachers also allows me to foster a critical discourse about the global learning to achieve a more consistent approach to its

implementation, with the aim of ensuring that trainee teachers have the opportunity to introduce a global dimension to their teaching practice, specifically within the area of science.

It is clear from these initiatives, that whilst benefits of global learning are evident (Appendix I, page 166), any sustainable changes to teacher practice must involve sustained guidance and support at a macro, meso and micro level. Understanding this within primary science is the focus of this study.

4.3 The global learning in primary science pedagogical framework

In response to the challenges and tensions surrounding global citizenship education outlined in chapter one, developing a framework to support a primary science education underpinned by the aim of supporting learners to develop the 'freedom to act in and within the world in which they live' (Biesta, 2013:742) was fundamental. The global learning approach to primary science was aimed to work with both trainee and in-service primary teachers with the integration of a global learning pedagogical approach to primary science education. In contrast to the programmes and initiatives described in section 4.2, the professional development workshops were tailored to the subject discipline of science using two underpinning frameworks:

- A global learning approach as defined by Bourn (2014): a pedagogical approach that puts learning in a global context, fostering critical and creative thinking, self-awareness and open-mindedness towards difference, understanding of global issues and action and optimism for a better world
- The Sustainable Development Goals (UNESCO, 2015a).

The global learning pedagogical approach was designed to enable teachers to underpin their science teaching and learning with a global dimension in order to ensure that it is both purposeful and relevant to our future global citizens. The approach was influenced by a transformative paradigm, as advocated by the analysis of successful global learning approaches discussed above. The idea originates from Mezirow (1991) which focused on adult learning and was later developed by Sterling (2011) with an emphasis on sustainable development. Transformative learning focuses not just on knowledge and skills, but on a better understanding of ourselves in relation to others and the world around us (Murray et al., 2013). As Sterling (2011) identifies, it helps the learner see things differently. Jicking and Wals (2008) explain that a transformative learning approach supports self-reflection and leads to behaviour change.

Research conducted by IDEAS (2017) identified the relationship between increased teacher confidence in delivering education for global citizenship with the introduction of related pedagogies. The global learning approach to primary science, therefore, aims to support practitioners in choose pedagogical strategies within their science teaching practice in line with a global learning approach. Essentially, the interest of this study is that global learning represents a shift in the overarching way teachers approach

primary science education, which requires them and teacher educators to consider a global pedagogical approach. With the view of embedding more transformative pedagogy, this research sought to investigate the effect of implementing such pedagogies on practitioners' sense of agency.

Table 4.1 below outlines how the professional development activities supported the global learning pedagogical approach to primary science, demonstrating how practitioners develop an understanding of and embedding the aims within their science curriculum.

Table 4.1: A table to show how the professional development activities supported a global learning approach to primary science education

Aspect of global learning approach	**Professional Development activities**
Explore and make sense of the big science issues;	Respondents were introduced to the SDGs, supporting them to be aware of global issues and how they linked to the science curriculum.
Think critically and creatively about topical science;	Respondents were introduced to / trialled a range of critical thinking and creative thinking pedagogical strategies which could be used within primary science programmes of study.
Be active participants in science enquiry;	Respondents were introduced to a planning framework which provided an opportunity to embed activities related innovation, action and problem-solving.
Consider different perspectives to scientific ideas;	P4C and critical thinking strategies were trialled and considered in relation to the science curriculum.
Communicate with and learn meaningfully about science discoveries from a range of cultures and countries;	Respondents were introduced to a range of resources celebrating historical and contextual science and global perspectives of science ideas
Develop an awareness of different approaches to scientific enquiry	Support for respondents to understand the importance for learners to have the space and skills to consider different approaches to answering scientific questions. Introduction of OSED strategies also supported this dimension of the approach.
Argue a position or view;	Discussion with respondents about the importance of spaces for critical thinking strategies within science – supported by planning framework.
Reflect on the consequences of their own actions now and in the future;	Consideration of learning outcomes which supported reflection, discussion and action (supported by planning framework).

Link science learning to take responsible action.	Consideration of learning outcomes which supported reflection, discussion and action (supported by planning framework).

Drawing on the analysis of global learning initiatives in Appendix I (p.166) and models of professional development identified in chapter three, a pedagogical planning tool (Appendix VII, p.182) was constructed with the aim of supporting teachers to consider the relevance of science to the personal lives and consider the application and relevance of their learning to innovation and responsible decisions / problem solving in their local and global communities. It also highlights a range of pedagogical strategies, cohesive with the global learning approach outlined within the analysis of global learning initiatives, which are aimed to enhance and develop global learning skills (Bourn, 2016).

The second dimension of this project was to support teachers in their own understanding of global issues using the SDGs (UNESCO, 2016). As highlighted in the previous section, it is evident that to have the confidence and motivation to integrate a global perspective into their pedagogy, teachers need to have a personal and up-to-date understanding of global issues. The 17 SDGs can provide a clear tool to ensure that teachers can confidently integrate global issues into their teaching (Simpson, 2016). These development goals also provide focused links to the primary science curriculum (as outlined in Appendix II, page 169), which will be reinforced on the supporting website (www.globalprimaryscience.co.uk) and twitter forum (@GloPriSci), enabling learning to be applied to global issues.

4.3.1 The principles of global learning in primary science

Through building on the approaches discussed above, the global learning in primary science was underpinned by an understanding of education as a transformative process which supports children to acquire knowledge, skills and attitudes to help them become active global citizens who are able to act on global concerns (Bourn, 2015). The recommendations from the impact studies outlined in Appendix I, page 166, alongside the effective professional development approaches discussed in Chapter two, enabled four main principles for the global learning approach in primary science to be identified. These are:

- The importance of developing a shared understanding of the purpose of primary science education in relation to the global learning aims.
- A clear conceptualisation of global learning as a pedagogical approach towards science learning and teaching (and the aligned pedagogical strategies).
- The Sustainable Development Goals (UNESCO, 2015a) as a framework to inform a holistic understanding of global issues that can be linked to science learning,
- Learning outcomes in science that include knowledge, enquiry, personal and real-world application.

The first principle, developing a shared understanding, acknowledges the importance of teachers and schools taking ownership of their science curriculum, and understanding its purpose beyond curriculum outcomes. It could be argued, in line with Foucault's (1998) theory of power, which is based on the understanding that power is based on knowledge and making use of knowledge, that it is important to relate this principle to the current Ofsted framework (Ofsted, 2019). As Ofsted provides a powerful influence on leadership and teachers (Perryman, 2018), the consideration of 'intent, implementation and impact' (Ofsted, 2019) may motivate practitioners and senior leadership to engage with the global learning approach. Previous research, as discussed in chapter three, highlights the importance of teachers relating their own values and beliefs to what they teach. Initiatives highlighted above also state the importance of developing a shared vision to ensure that teachers can support each other in the development and continuation of a new approach such as this one. As a result, developing a shared understanding of the purpose of primary science based on teacher beliefs and values and drawing links to the global learning aims will be a key principle.

Building a clear understanding of global learning as a pedagogical approach aims to aid teachers in reviewing their science curriculum and how it is delivered. As recommendations assert, teachers need support in moving beyond a view of global learning as a charitable endeavour (Simpson, 2016) or a bolt-on to what is already being taught, as identified by the Global Learning Programme (2017). The global learning in primary science framework, therefore, models a range of pedagogical strategies which are cohesive with a global learning approach (Table 4.2, page 47), along with signposting to resources which support them. Recommendations, as identified in Table 4.2, page 47, demonstrate the need for supporting resources, specifically linked to the science curriculum. As discussed above, it is also important that teachers can see these strategies being modelled in practice, to see how they benefit and engage the children. As indicated, critical thinking activities, Philosophy for children, Open Spaces for Dialogue and Enquiry, and other dialogic activities (linked to Wellcome Trust's Explorify) all support the global learning pedagogical approach and enable teachers to develop more critical perspectives to their teaching. The table 4.3 on page 49 below demonstrates how these strategies link to the global learning approach and related resources that support teachers.

Finally, the last principle focuses on the importance of helping teachers to consider the purpose of learning beyond accountability measures. As Freire (2003: 100) articulates, 'the role of the teacher is not to impose on the student a passive body of knowledge but challenge epistemological curiosity of the student'. Subsequently, the approach aims for teachers to draw on their own beliefs about science learning to facilitate a change of pedagogical practice. The transformative approach to professional development reflects the views of Dewey, Freire and Reiss discussed in Chapter two, considering the impact of learning to support children personally and for them to support others, as global citizens. In summary, it aims for teachers to critically reflect on the beliefs that give meaning to their science practice, supporting what Mezirow (1991) refers to as a 'perspective transformation' positioning teachers and learners as agents of change.

Table 4.2. Pedagogical strategies within the global learning approach to primary science

Pedagogical strategy	**Link to Global Learning Pedagogical Approach**	**Resource support**	**Example in primary science (modelled to teachers)**
Critical thinking	Problem solving - finding appropriate solutions for problems Critique, Critical questioning, question formulation Argumentation-defending ideas, discussion and debate Bailin et al (1999) argue that critical thinking instruction at the primary school can include teaching students to e.g.: value reason and truth; be open-minded; respect others during discussion; be willing to see thinks from another's perspective.	PSTT curriculum material	Values on a line: 'Which sport is the healthiest?' This modelled the importance of discussing what 'healthiest' means and working together to agree on the order, then comparing it with other groups. The children can then investigate impacts of different exercise by measuring pulse rates, breathing, and other effects. (See Appendix VI, p181)
Philosophy for Children/ Community of scientific enquiry	Characterised by care and collaboration as well as critical and creative thinking. The purpose of a community of enquiry is to join together to address a question of common concern, and through the exchange of different points of view, to reach a better understanding.	Sapere	Using a book to provoke discussion around a big question: 'What is rubbish? What is treasure?' from the story Paperbag Prince by Colin Thompson. This activity allows children to question their ideas and listen to others. This activity would lead on to an exploration of materials, their properties and uses. (See Appendix VI, p181)
Open Spaces for dialogue and Enquiry	A methodology for the introduction of global issues and perspectives in educational contexts. The development of critical literacy and independent thinking are the central aims of this initiative.	Osde Methodology	By posing the statement: 'All fruit and vegetables should be grown in our own gardens', we model the approach that classroom discussion is a safe space to have different opinions, all of which should be respected. Again, this activity provides stimulus for enquiry regarding what can be grown in our garden depending on the season and climate (See appendix VI, p.181).
Creative Thinking	Being able to draw on science knowledge to solve problems and be innovative.	Practical Action STEM challenges	We have used a range of practical action STEM challenges to demonstrate how science can be used to challenge children to solve a problem, such as to design and make a floating garden so farmers can still grow crops during flooding seasons. This activity involves children drawing on their knowledge of properties of materials and forces. (See Appendix X, p. 184).

4.4 The professional development structure

To integrate the principles described above, a structure for the professional development of global learning in primary science was developed. Table 4.3, below outlines the structure of the global learning in primary science professional development, indicating the rationale of each aspect and the resources and tools used.

Table 4.3: Global Learning in Primary Science Professional Development Structure

Activity Item	**Principle / rationale behind activity**	**Tools / resources**
1.Global Learning in Primary Science Attitude survey	Developing a shared understanding of global learning in primary science by facilitating teachers own beliefs as a baseline for this.	This activity is not only part of the data collection but allows teachers to reflect on their own vision and beliefs surrounding primary science and global learning (Appendix III, p177).
2. What is the purpose of Primary Science Education?	Developing a shared understanding of global learning in primary science.	Using the aims of primary science from top performing countries around the world (according to OECD ranking) to help teachers identify words and phrases which underpin their vision of the purpose of primary science – a team activity allowing teachers to collaborate and agree. (Appendix IV, p. 178)
3. How do the aims of global learning match the aims of primary science education?	Facilitating a clear understanding of global learning as a pedagogical approach.	Matching the global learning approach to the aims of primary science (Appendix V, p180)
4. How can we integrate sustainable development goals into the primary science curriculum?	Using the SDGs to underpin and support teachers in developing an understanding of relevant global issues and how they can integrate these into the curriculum.	An information sheet defining the SDGs and how they are relevant to learning is given to teachers, along with a table of programmes of study in the science curriculum. Allowing teachers to come up with their own links and ideas of how to integrate these issues into the science learning is fundamental to them taking ownership of their planning and delivery (Appendix II, p169).
5. What pedagogical strategies can be used to promote a global learning approach in primary science?	A carousel of modelled activities allows the teachers to see how the strategies can be put into practice, along with a supplementary hand out on further ideas.	See appendix VI, p181
6. What resources are available?	Providing guidance and support: an online platform and handout provides guidance on resources that can be used to support a global learning approach. Research has shown that this is fundamental to a cohesive and successful approach.	A handout is given to teachers to provide guidance for resources which support GL in science (appendix VII, p182). An online platform also provides relevant links in relation to each area of the Primary Science National Curriculum this is continually developing and aims to include all relevant organisations and links to create a more cohesive approach to GL in primary science.

7. A template for planning schemes of work	Ensuring science has a real-world purpose. In order to ensure that global learning does not become discrete project work, or just work related to the environment, a template has been created to underpin planning with a GL focus.	Examples of how the template is completed is done through modelling (see appendix VIII,p182)
8. A three-month follow-up	Previous projects have highlighted the importance of continued professional development training to support reflection, confidence and sustained integration of GL strategies.	A visit to the school and further shared resources and ideas, coordinated with the science coordinator of the school where possible.
9. A six-month follow up		

4.5 Global learning in primary science aims and theory

The empirical phase of the research explored whether professional development of a global learning pedagogical approach could develop primary teachers' engagement with and ownership of the primary science curriculum, through demonstrating the purpose of primary science beyond content and skill development. This aim was motivated by the concern identified in recent research conducted by Ofsted (2019) highlighting the declining status and quality of science teaching and learning in primary schools. The research also considered how SDGs and a global learning approach could provide a framework for teachers to integrate global dimensions into the science curriculum.

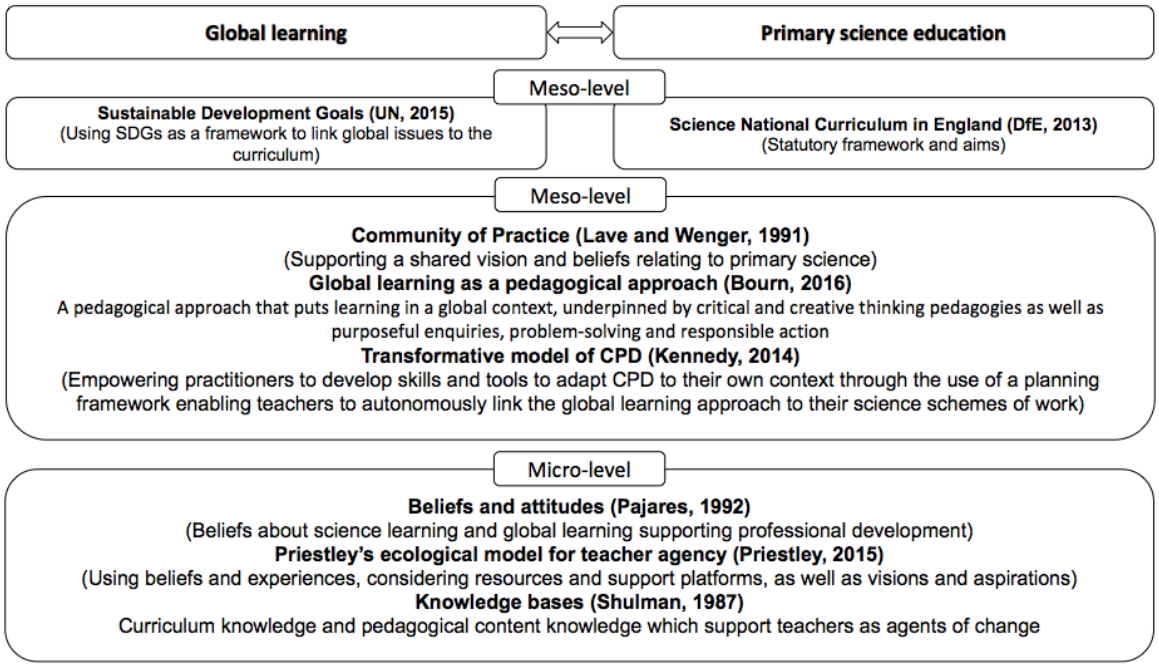
4.6 Chapter Summary

This chapter focused on the development of the conceptual framework underpinning the global learning in primary science approach and the professional development model used within this study. Effective professional development includes an underpinning pedagogical and theoretical framework as well as an understanding of how practitioners can be agents of change, according to Priestley's ecological framework (2017). This chapter, therefore, focuses on how these aspects are integral to the global learning in primary science approach.

The pedagogical and theoretical framework informing the professional development activities were underpinned by a transformative approach. For example, the initial activity asked teachers to consider the purpose of primary science, as well as how the sustainable development goals were relevant to the National curriculum programmes of study (DfE, 2013). The planning frameworks introduced to the teachers aimed to enable them to consider how competencies could be developed and how their learning content (their programmes of study) could impact children's personal development and community development (Appendix VII, p.182). A key point when considering the pedagogical framework was the importance of engaging teachers in transformative learning theory (developed by Mezirow, 1991), enabling them and their pupils to participate in 'evidence and ethics-based decision-making processes in an increasingly uncertain world' (Taylor, 2015). The theoretical framework

informing the global learning in primary science professional development is summarised in figure 4.1 below. The next chapter will outline the study's methodology and methods, demonstrating how data was collected and analysed in relation to the global learning in primary science professional development, engagement and influence on practitioners.

Figure 4.1 A theoretical framework underpinning the global learning in primary science CPD



CHAPTER FIVE METHODOLOGY AND METHODS

5.1 Introduction

This chapter outlines the principles of research and methodology that were used to carry out a mixed-methods study, using both quantitative and qualitative methods (Creswell and Plano Clark, 2011). The purpose of the study, research paradigm, theoretical framework and research design will also be addressed.

This study aimed to explore the extent and ways in which a global learning approach could be used to develop the purpose and value of science in primary schools, supported by professional development (described in the previous chapter). In order to explore this aim, the following research questions were used:

1. *In what ways do stakeholder beliefs and attitudes to global learning in primary science influence their engagement with the approach?*

2. *How can a global learning approach to primary science be integrated into ITE and professional development?*

3. *How does a global learning pedagogical approach support greater motivation and engagement with the primary science curriculum?*

In order to draw any conclusions to these research questions, the process of data analysis was considered. As Lincoln and Guba (1985) outline, demonstrating the reliability and validity of qualitative (and therefore mixed-methods) research requires the consideration of truth value, consistency, neutrality and applicability.

5.2 The underpinning research paradigm

Research paradigms shape how researchers views the world around them (Schwandt, 2001). As discussed by Scotland (2012), it was crucial to acknowledge underpinning values and assumptions of reality to explain the chosen methods, interpretation and potential use of research findings for this study. The ontological and epistemological positions underpinning this study provide a justification for the research design, methods and approaches to analysis (Creswell, 2017). They also guide the interpretation of data and research conclusions (Bailey, 1994).

Much discussion in educational research methods focuses on the distinction between quantitative and qualitative research (Creswell, 2008). This study, however, is underpinned by the belief that in order to best address the research problem, multiple paradigms should be employed, whilst understanding the

warnings of Creswell (2008) about the possible tensions between them. Pragmatism, an approach emphasising the importance of shared meanings and joint actions (Morgan, 2007:67), supports the understanding that theories can be both contextual and generalisable by considering the transferability to different situations (Creswell, 2009). Within pragmatism, transferability of research is strengthened by both breadth and depth of data provided by the connection of both quantitative and qualitative approaches. Subsequently, connecting quantitative data to qualitative data within this study aimed to inform how global learning could support primary science was viewed by multiple stakeholders in different settings.

This research also considered that within the ever-changing cultural, historical and political climate, an approach that was most useful to answer the research problem was seen in a pragmatic epistemology (Dewey, 1999). In this case, it was to consider the ways to improve the quality of primary science education whilst enabling children to have a broader perspective of their interdependence with the world around them. Pragmatism aligns with social constructivism in its commitment to seek out and accommodate many different perspectives in any social setting where decisions are made (Vygotsky, 1986; Creswell and Plano Clark, 2011). It also emphasises the importance of using a mix of quantitative and qualitative methods to answer research questions (Johnson and Onwuegbuzie, 2004; Onwuegbuzie and Johnson, 2006). Agreeing with Erickan and Roth (2006), this research adopts a continuum of generalisability, rather than a dichotomy between quantitative and qualitative research. The breadth of viewpoints collected from the quantitative attitudinal survey are still aimed to support generalisations whilst the qualitative data of semi-structured interviews, reflections and engagement with the global learning approach explored and challenged individual perspectives and contexts within this study.

Considering the literature reviewed in the previous chapters, it was evident that this research was underpinned by several theoretical fields in relation to the development of primary science learning and the place of global learning (as detailed in figure 4.1), which include professional development, belief systems, agents of change, science learning and global learning. With these constructs in mind, the participants and their engagement with global learning in primary science were the focus of the study, resulting in the construction of multiple realities (Denzin and Lincoln, 2011). More specifically, as the delivery, quantity and content of primary science is influenced by a range of stakeholders, it was important to consider the realities of different participants: including advisors of primary science, head teachers and school senior leadership team, leaders of primary science, teachers, and pre-service teachers. This research was therefore aligned with social constructivism in the centrality of language as an important mediator of meaning making in relation to the different perspectives (Vygotsky, 1986).

Whilst taking a pragmatic, social constructivist position, it was assumed that collective meaning making could inform individual and group action, subsequently shifting beliefs, attitudes and approaches to science teaching and learning (with a potential focus on the wider community responsibility). As discussed by Bergold and Thomas (2012), this study followed the assumption that as the researcher,

my own background, perspectives and contexts in which I worked would shape the research outcomes. However, rather being a study *on* the participants being researched, it aimed to ensure a balance between the researcher and researched to maximise the potential for knowledge creation; through meeting, interacting with and developing an understanding of each other. Denzin and Lincoln (2011) propose that such enquiry should be naturalistic in that it is done in the place where practice occurs, thus findings may differ in another context. However, as Jacobs (2016) explains, the social constructivist nature of the enquiry, which combines theory and practice, action and reflection with participating stakeholders who seek solutions to concerns and issues, aimed to be transformative rather than just informative.

5.3 Adopting a mixed-methods tools

As Ponce and Pagan-Maldonado (2015: 112) discussed, if education is defined as a 'cultural phenomenon', educational research should focus on the complex social relationships (for example. between senior leaders, educational advisors, teachers and children) that occur in schools to produce learning. As discussed, this study combined quantitative and qualitative methods to take advantage of the benefits of each approach. Creswell (2002) argued that the use of more than one method allows for better quality and scope. Whilst Onwuegbuzie and Johnson (2006) warn of the possible challenges of dealing with conflicting results and being able to analyse quantitative data qualitatively, they also highlight how qualitative data can provide a fuller picture. Tashakkori and Teddlie (1998) and Creswell and Plano Clark (2011) argue that when adopted thoughtfully, they can be used flexibly to answer the research questions. A quantitative attitude survey was used to compare different stakeholders' attitudes towards global learning in primary science in an objective way (theory testing). This data was then elaborated on using semi-structured interviews, engagement with the approach, reflections and evidence of global learning in primary science in case study schools. A researcher reflective diary and reflective interviews were also used to enable a focused exploration of the influence of the global learning professional development on pedagogical practice and teachers' beliefs towards global learning and an understanding of themselves as agents of change. Whilst being critiqued for their inability to provide generalisable conclusions (Creswell, 2009), the focused, but flexible, nature of a semi-structured interviews allowed for a narrative description of different perspectives, thus enabling the research questions to be explored in depth.

5.3.1 The Embedded Experiential Design

Creswell and Plano Clark (2011) state that there are four types of mixed-methods research design: embedded, explanatory, exploratory and triangulation. This study followed an embedded design in which quantitative data was embedded in a qualitative design. The quantitative data was used to answer specific questions about beliefs and attitudes towards global learning in primary science. The data from the attitudinal survey was also used to inform the semi-structured interviews. Both the quantitative survey and semi-structured interviews supported the development of the global learning

in primary science approach professional development workshops (the experimental intervention), as outlined in Figure 5.1 which can be found on page 56. Creswell and Plano (2011) highlight that an embedded mixed methods approach is useful when considering an experiment design and answering research questions at different levels. In this study, the major purpose was to explore the attitudes to and engagement with a global learning approach in schools in England. Considering different stakeholder perspectives and priorities was important to seek feasible solutions to the research questions. Subsequently, the quantitative attitudinal survey provided a comparative summary of attitudes of each stakeholder group towards global learning in primary science. The semi-structured interviews with a portion of each stakeholder group were used to explain any generalisations as well as consider individual perspectives, which in turn informed the global learning in primary science professional development. Finally, reflective diary entries, interviews and sample evidence (displays, children's work, science planning) from three case study schools provided qualitative data relating to the impact of the study. In summary, from a macro level, quantitative data with supporting qualitative explanations aimed to influence the policy context of primary science; at a meso level considering how different stakeholder groups can be supported to influence a changing approach to enhance primary science provision, and from a micro level, the qualitative exploration of interviews, reflective diaries and sample evidence from three case study schools aimed to consider professional autonomy and practitioners' pedagogical approach to primary science education.

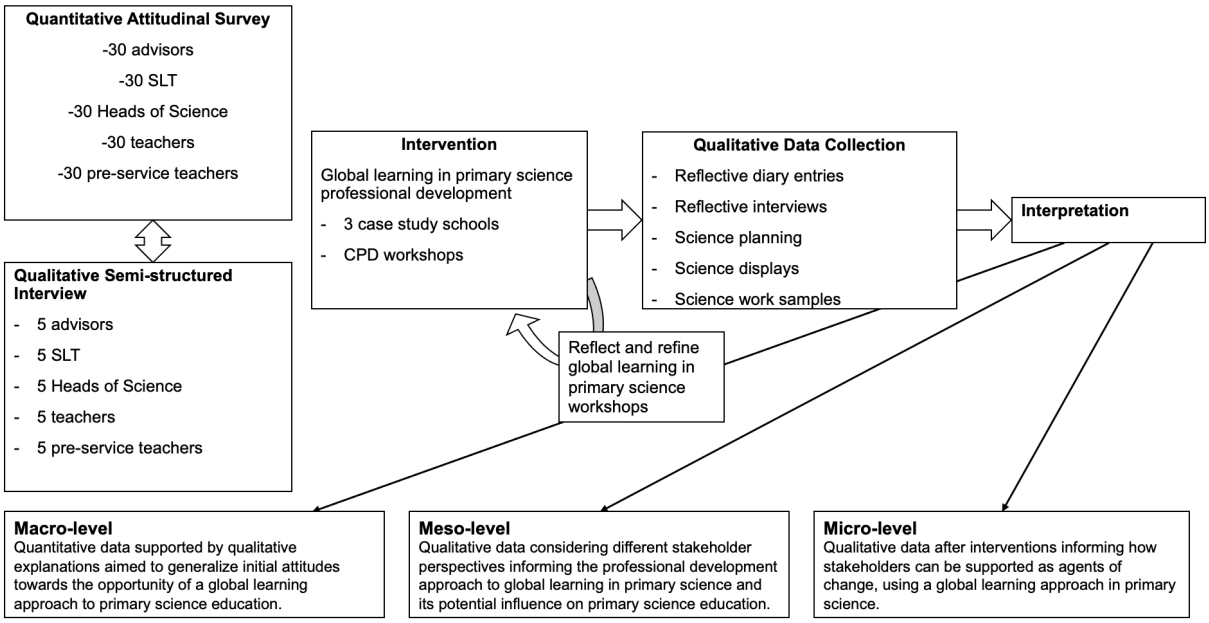
Creswell and Plano Clark (2011) also support the use of NVivo to analyse and develop themes from the qualitative data to facilitate the interpretation of the quantitative data, and subsequently inform the development of the experimental intervention (which in this case is the global learning approach to primary science). It is important, however, to be aware of potential issues with credibility, as defined by Bryman (2006) as the employment of approaches that enhance the integrity of findings. When analysing interview data into themes, to maintain credibility, it was, therefore, important to ensure that responses were not mistranslated, or confirmation bias was not imposed by the questions asked. As a result, it was important to remain reflexive throughout the interview process and thematic analysis, being constantly aware of my own influence and interpretation, as suggested by Dowling (2006). The ways in which data was analysed is presented in the coding table below:

Table 5.1. Thematic analysis table

Main theme	Sub-theme	Description
Individual beliefs about science	Knowledge	Points related to facts, concepts, foundational knowledge about the world around us.
	Skills	Responses related to the nature of science including skills to support investigations and enquiry.
	Attitudes	Responses related to the importance and value of science.
Attitudes / beliefs about a global learning	Knowledge	Responses related to ways in which a global learning approach may support curriculum content delivery (concepts).

approach to primary science	Skills	Responses related to ways in which a global learning approach may support curriculum content delivery (skills)
	Attitudes	Responses related to ways in which a global learning approach may support engagement and value of science learning / and teaching.
Professional development / supporting agency	Science-specific professional development	Responses sharing ways in which global learning can be linked to science education / the primary science curriculum.
	Resources / support platforms	Responses mentioning tangible resources such as website, social media, ideas for classroom activities.
	Priorities for primary science CPD	Identified priorities to support teachers delivering primary science lessons.
	Strategies / supporting a global learning approach	Pedagogical strategies mentioned that could be developed within a global learning approach, for example: critical thinking and creative thinking in primary science.

Figure 5.1: A diagram depicting the embedded research design



Over a one-year period (October 2018 – October 2019), heads of science and in-service trainee teachers were supported through professional development sessions, and an online resource platform (the experimental intervention). As the previous initiatives and research suggest (Appendix I, p.166 and Adey, 2004), effective professional development is collaborative. With the consultants and advisors, students and teachers, they were asked to work with people whom they worked frequently with, to consider how they might integrate the global learning approach within their schemes of work (for example, students and teachers working with those in the same year group, advisors working with those within similar professional circles). After the sessions, teachers were then asked to volunteer to be contacted later in the academic year to capture their reflections using reflective interviews. Social media platforms such as Twitter and a dedicated website were used to enable practitioners to share

activities and outcomes of the approach. Data collection also included asking to look at planning, rather than focusing on observing teaching and learning, as the focus was on the motivation of teachers to integrate a global learning approach into their practice. Whilst reflective interviews from the three case study schools occurred after the experimental intervention phase, the study was not considered to be action research, as the impact of the workshops was not being directly measured.

The global learning in primary science approach capitalised on my position as a primary science lecturer and lead facilitator of STEM CPD to work with a range of respondents in the community, see Table 5.1 on page 55. Over a one-year period (October 2018 to October 2019), three case study schools, teachers and in-service teacher trainees were supported through professional development workshops, along with an online resource platform.

5.4.1 Recruiting schools and individuals to the project

As identified by Newby (2014: 261), the nature and purpose of the research informed the use of non-probability and purposive sampling. It was important to ensure the sample included specialist perspectives (including primary science advisors, senior leadership teachers, heads of primary science, pre-service teachers and teachers) but it was also important to use participants that were convenient to recruit, within the time frame of data collection, hence the use of convenience sampling (Newby, 2014:257). Subsequently, considering representativeness and bias was important in the analysis of findings. advisors of primary science were recruited via colleagues from the primary science network which has been developed through courses and conferences. SLT members were invited either as partnership schools or through links with the Masters in Education programmes at my university, none of whom I worked with directly. Heads of primary science were recruited through professional development links and this snowballed into the recruitment of teachers. Finally, pre-service teachers were invited to participate during the taught periods of their course, not directly by myself, where they were already on the university campus. As a result of the attitudinal survey, respondents were then asked if they were happy to be contacted to participate in further elements of the study (namely the semi-structured interviews and the global learning in primary science professional development workshops). Some participants were also recruited through selecting to attend a workshop at the Association of Science Education Annual Conference; and with consent, participated in further elements of the study.

Within the three case study schools who engaged in the global learning approach to primary science professional development, my own reflective diary, along with further reflective interviews and samples of planning and science work were obtained in order to consider the effectiveness of the approach. As an iterative approach, each workshop and semi-structured interviews informed amendments to the subsequent global learning in primary science workshops and interventions.

Table 5.2 GLPS Workshop Venues and dates

Venue / Group	Date
School A	October 2018
School B	November 2018
School C	December 2018
PSQM lead science teachers	November 2018
ASE Annual Science conference	January 2019
ASE Annual Science conference	January 2020
Year three elective science undergraduate pre-service teachers	January 2019
PGCE primary pre-service teachers	October 2018

5.4.2 The participants and case study schools

Overcoming the challenges of our increasingly interconnected and competitive world requires all citizens to have a better understanding of how science can enable them to participate actively and responsibly in science-informed decision making and knowledge-based innovation (European Commission, 2015). Furthermore, research informs us that the biggest impact on children's school performance in science is the quality of teaching they receive (Wellcome, 2020). To provide high quality, inspirational lessons, CPD and ITE must ensure that teachers have the skills, knowledge, confidence, and passion they need to deliver a relevant and engaging primary science education. Opportunities for teachers to engage in professional learning and development must be supported by school and subject leadership. This study, therefore, involved a range of schools, teachers, advisors, and pre-service teachers at various stages of the research, considering their influence on a potential change in approach (see Appendix IX, page 185).

Within an embedded research design, a larger sample was required for the quantitative attitudinal survey to allow for generalisability. As discussed by Cohen et al., (2018), the sample size was informed by the need to compare each stakeholder group. To have a confidence level of 95%, 30 respondents for each stakeholder group were therefore necessary, resulting in 150 respondents in total. From each stakeholder group, it was decided that one-sixth of each group (5 respondents) would be interviewed to elaborate on the survey data. In terms of the time required to conduct the semi-structured interviews, as well as ensuring an adequate number of each group volunteered to conduct the survey, 5 respondents was both achievable and would enable me to gain further insight from a range of people. Braun and Clarke (2006) agree that for thematic analysis, the number of respondents must allow for themes to be uncovered. Within the scope of this study, conducting twenty-five semi-structured

interviews in total, enabled patterns to emerge. Finally, three case study schools were explored in more detail to ensure depth of analysis.

The sample is summarised above in Appendix IX (page 183), considering the recruitment of schools and teachers who participated in the workshops, and the identification of respondents for the semi-structured interviews.

5.4.3 Primary Science Advisors

Within the context of primary science, there are a range of people who train, consult and support the professional development of those who deliver primary science education. As a result of the diversity of responsibilities, defining the role of a primary science advisor was challenging. However, for this study, the ASE futures definition as those 'providing support and voice for ITE and CPD, fostering high quality professional learning for future generations of science teachers' (ASE, 2019) provided an overview. Within this study, they included primary science lecturers who design and deliver modules to train teachers in ITE institutions, as well as other individuals of the primary science education community, providing professional development and supporting primary science education resources to primary schools and teachers. This community is complex. In some cases, it was difficult to classify primary science advisors. As previously stated in the CUREE report (Cordingley et al., 2015), subject-specific advisors can be defined as external subject-specific experts who conduct CPD in schools, as well as those who deliver internal programmes. The report also included 'critical friends' from Higher Education Institutes and Local Authorities as well as internal advisors. Within this study, the discussion will remain aware of the increased blurring of internal and external boundaries that overlap, for example, some subject-specialist teachers also lead external CPD. Notably, as highlighted in section 2.6, one of the science advisors in the study was both a school-based subject lead as well as a PSQM hub leader, supporting other science subject leads.

5.4.4 Primary Head Teachers and Senior Leadership Team

As identified in a Wellcome Trust report (2019:20) regarding the state of primary science education in schools, the passion of the headteacher and senior leadership team was often seen to be pivotal in prioritising, valuing and changing practice in primary science, especially when there are so many competing pressures. Whilst two head teachers participated in the project, the uptake of whole school participation instigated by the senior leadership team was low. As a result, this was an area explored further by semi-structured interviews. As Hanley et al., (1996) suggested, whilst they may have been an ardent belief that their pedagogical practice was already sufficient, the competing pressures of accountability measures and managerial challenges were more likely to have an impact on their ability to engage in this initiative.

Within the schools in which a global learning in primary science workshop was delivered, the presence of senior leadership team was only seen in one school. Subsequent motivation and sustained engagement of colleagues was monitored, especially considering the impact of senior leadership support. In relation to Chapter three, both Guskey (2000) and King et al., (2015) articulate the difficulty of operationalising new pedagogical approaches if it is not embraced by the whole school community. Resultantly, the question of how to engage primary school senior leadership in subject-specific professional learning, as the reflective diary highlights (see Appendix XI, p.187) became an area to follow up with the case study schools.

5.4.5 Primary Science Subject Leaders

As defined by another Wellcome Trust report (2017c:2), a primary science subject leader is the person in a school who is responsible for ensuring that the science element of a broad and balanced curriculum is delivered effectively to ensure children make good progress in their understanding of science. According to the same report, these subject-specific leaders should value science, understanding its importance and relevance of science to our lives, taking responsibility for developments that affect school policy, the effects they have on the development of children's identities and the implementation of a whole-school vision, advising and supporting colleagues on the pedagogy and appropriate resources (Wellcome Trust, 2017a:6). With an awareness of their responsibility for ensuring they and their colleagues have access to Continued Professional Development (CPD) to ensure the effective delivery of science, it was important to explore what they valued as essential aspects of primary science education. Evaluating subject leader beliefs, attitudes and exploring their perspectives and implementation of a global learning approach to primary science, was therefore seen as pivotal to the data collection. As identified by Wellcome Trust (2019), increasing the importance of science across a school is seen as a key solution to address some of the challenges related to delivering quality primary science. The role of the primary science leader is also key to improving confidence and teaching across a school (Wellcome, 2017a). The relationship between leader attitudes and links to global dimensions, was therefore a key area of data collection.

Within this study, primary science subject leaders were from my university's partnership schools, some of whom also mentored trainee teachers, adding an extra layer to their responsibility (and influence) in the development of primary science. Of the thirty science subject leaders surveyed, they were all active in their own professional development, evidenced by the fact that surveys were conducted at primary science conferences, or other professional development courses. They had various levels of experience, some being new to the role after their Newly Qualified Teacher (NQT) year, whilst some being in their position for over ten years. This was noted in their overview profiles (Appendix XVII, page 201) with an awareness of how experience can influence beliefs, attitudes and agency (Biesta, Priestley, and Robinson, 2015).

5.4.6 A teacher of primary science

A teacher of primary science, the definition agreed by nine key organisations*[1] (Wellcome Trust, 2017: 3), should have a secure understanding of science concepts within the primary science curriculum and they should also understand and model different methodologies suitable for delivering the primary science curriculum, including problem-solving and addressing gender stereotypes. Confederation of British Industry (CBI) (2015) highlighted that primary teachers, as generalists, do not often have science qualifications past GCSEs, with only an estimated 5% of teachers holding science related degrees. CBI (2015) went on to highlight that a lack of confidence in science due to its fast-advancing landscape, could have a negative impact on science.

It was, therefore, fundamental to evaluate teachers' attitudes towards global learning and its relevance to primary science, exploring their motivation to develop and embed related methodologies. The teachers recruited in the global learning primary science approach were either recently qualified teachers (RQTs) from a university, and teachers who were involved as part of school professional development. None of these teachers had indicated a special interest in science, making their group interesting in relation to competing initiatives and national foci, considering the difference between specialist and generalist primary practitioners.

5.4.7 A pre-service teacher of primary science

Trainee teachers were recruited from both the undergraduate route into teaching as well as the postgraduate route into teaching. Although the undergraduate primary education teacher training programme offers a route in which students can elect science as a specialist subject area, it was decided that students were not specifically chosen from this group, to explore the norm in relation to primary teacher training. Gaining the perspectives of all generalists would provide a better understanding of factors that motivated students to embrace different pedagogical approaches.

Wellcome (2017a) emphasised the restricted period for all ITE courses, resulting in trainees generally being responsible for the development of gaps in their subject knowledge, stating that more than two-thirds have not studied the subject beyond GCSE. Science input by all providers, including the university used in this study, focuses on pedagogical content knowledge and practical science (Wellcome, 2017a). Furthermore, the consequence of timetabling within school placement (which focuses on English and maths) results in a limited opportunity to observe and teach science during ITE courses. Considering Initial Teacher trainee attitudes and perspectives towards global learning in science (as well as science in general) was therefore pivotal to the consideration of engagement and motivation towards the global learning in primary science pedagogical approach. It was very straightforward to recruit pre-service to conduct the attitudinal survey, due to their proximity to myself as the researcher,

[1] Association for Science Education (ASE), Campaign for Science and Engineering (CaSE), Institute of Physics, Institute of Engineering and Technology, Primary Science Quality Mark, Royal Society, Royal Society of Biology, Royal Society of Chemistry and Wellcome.

and 27 out of 30 were happy to be contacted to conduct further workshops related to global learning in primary science. It was, however, much more challenging to find time to conduct interviews and further global learning in primary science workshops with these respondents, because of assignment and placement pressures. This challenge of sustained engagement of different stakeholders in primary science CPD is an important consideration in relation to the overarching research question.

Table 5.3 Table of research participants

STAKEHOLDER	Initial Attitudinal Survey	Initial Qualitative Semi-structured interviews
Primary Science advisors	**30**	**5**
Primary School Senior Leadership Team (SLT)	**30**	**5**
Heads of Primary Science (HOD)	**30**	**5**
Class teachers	**30**	**5**
Pre-service teachers	**30**	**5**
Total	**150**	**25**

5.4.8 Participants of the global learning primary science workshops

The global learning in primary science workshops were delivered in a range of settings including three partnership schools, part of a specialist primary science elective module on an ITE programme, an international primary science workshop, and an optional PGCE workshop. Although all these participants completed the initial attitudinal questionnaire and workshops, not all of these engaged with further workshops and global learning professional development (and subsequent semi-structured interviews). This was significant and became part of the research discussion, as exploring reasons and constraints of sustained engagement in science-specific professional development was an important aspect of the study.

5.4.9 Semi-structured interview selection

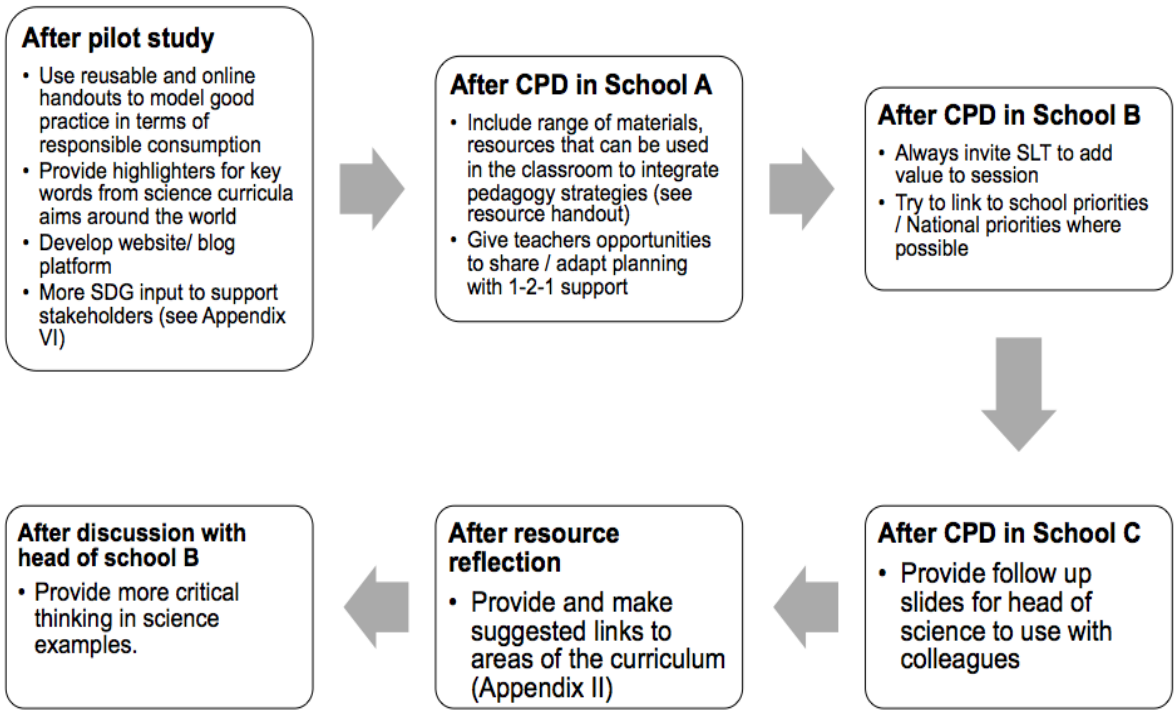
For the semi-structured interviews, purposive sampling, a non-random method of sampling was used whereby information-rich cases were selected. As Patton (2002) highlights, the purpose of this was to enable a greater depth of information about the issues central to the importance of the research questions, as well as to explain some of the patterns identified in the quantitative attitudinal questionnaire. As discussed above, to conduct a thematic analysis of the qualitative data, five individuals from each stakeholder group were interviewed. In line with Creswell (2007) who suggested that a minimum of 5 interviews are required, it was decided that 5 interviews from each stakeholder group (25 in total) would provide adequate saturation of themes in relation to the research questions. In order to recruit these, those who agreed to be contacted after the project workshops were contacted

to ask for further support in the study, being conscious that those who agreed to further contact may have a greater interest than those who did not. Approaching primary science advisors from key organisations allowed for interesting perspectives to be considered in relation to the research focus. In agreement with Patton (2002), whilst standardised information from a large and statistically significant sample was useful to highlight patterns and create generalisations, focusing on a small number of carefully selected participants for the semi-structured interviews provided rich data to address the research questions.

5.4.10 Data Sources

Due to the focus of the research study on the global learning in primary science, it was necessary to be pragmatic and adaptable in terms of data collection. It was important to reflect on how participants responded to the approach. It was also important to be responsive to a range of data, such as dialogues, suggestions and ideas which arose through the workshops. Using such an iterative approach (Srivastava, 2009) meant that after each workshop, elements of the workshop were changed and refined. Figure 5.2, on page 68, provides a summary of how aspects of the research informed changes to the global learning professional development workshops.

Figure 5.2 Iterative changes to the global learning in primary science professional development



The three case schools which volunteered to share how they implemented the global learning in primary science provided evidence in different ways and at different times, which can be seen in table 5.4 on the page below.

Table 5.4: Implementation of the Global learning in science workshops in case study schools

School	Initial intervention	Data Collected
A (One form entry, 20% pupil premium)	October 2018	Semi-structured interviews of head of science and teachers Samples of children's work
B (Three form entry, 7% pupil premium)	December 2018	Semi-structured interviews of head of science and teachers Example of Global Learning in Science whole school themed week
C (Two form entry, 5% pupil premium)	September 2019	Semi-structured interviews of head of science Schemes of Work

In terms of the interview questions, these also had to be adapted to relate to the experiences of the different respondents.

5.4.11 Professional development session feedback (Pilot study)

The attitudinal survey and professional development session were first delivered to a small group of ten individuals including advisors, teachers, heads of department and pre-service teachers to gain feedback on the structure and delivery. Acknowledged by Baker (1994: 182-3), piloting the attitudinal survey was advantageous in ensuring it was both valid and reliable, thus feedback was used to refine the survey's dissemination. It was also important to consider how the global learning workshop was also delivered and what data could be collected. During subsequent delivery of the professional development session, reflective notes were made in relation to participants' responses to the it, approaches and strategies, see Appendix XI, p.187. These reflections were unstructured and were used to develop and improve the global learning in primary science professional development in an iterative process, as well as provide data in relation to the research questions. It was also identified that to conduct the attitudinal survey accurately, respondents needed an initial understanding of the global learning approach to primary science. This was, therefore, integrated into subsequent workshops.

5.4.12 Reflective diary

Keeping and using a reflective diary aimed to make the researcher thoughts, feelings, opinions and experiences visible and part of the design and interpretation of data. As Denzin (1994) highlights, to reduce the problem of bias in qualitative research, a reflexive approach was employed. As well as adding 'methodological rigor and paradigmatic consistency' (Ortlipp, 2008: 704), critical self-reflection allowed for changes in the research design and approaches taken. Furthermore, having been a primary school teacher for over twelve years and being a teacher trainer and professional development facilitator, a reflective diary enabled me to identify and consider my position in relation to the research

at all stages. After each significant event (workshops, interviews and observations), a reflective entry was written, considering thoughts and subsequent actions (See Appendix XI, p.187). As Scheurich (1997) argues, my thoughts, feelings, desires and experiences may have impacted on the interviews but were not necessarily visible in the transcriptions. Resultantly, the reflective diary aimed to identify such reflections and added rigour to the non-linear research process. The reflective diary entries were also used as a data source to answer the research questions related to the strategies used to challenge teacher attitudes towards the purpose of, and approach, towards primary science education, a list of these and an example are included below.

Reflective diary entries

a) Pilot workshop
b) Recruitment process
c) Global learning attitude survey with NQTs
d) Exploring ways to engage schools in global learning professional development
e) Case study school A reflection of professional development
f) Case study school B reflection of professional development
g) Case study school C reflection of professional development
h) Global learning in primary science resource development
i) Academic Network of global learning conference presentation
j) ASE conference workshop reflection 2019
k) ASE conference workshop reflection 2020
l) School B Head of Science Department Interview reflection
m) School C Head of Science Department Interview reflection
n) School A Head of Science Department Interview reflection

Figure 5.3 A reflective diary template

What: What have I learnt? What did I hope to learn? What surprised me?	
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science? Now what might be the consequences of this action?	
Additional comments	

5.4.13 The quantitative survey

As a university lecturer as well as a primary science CPD facilitator, recruiting respondents from each stakeholder group was largely easy through voluntary agreement during university teaching sessions (pre-service teachers), professional development workshops (teachers and heads of science), partnership school visits (SLT and teachers), as well as primary science conferences (advisors).

The use of an attitudinal survey was based on the assumption that the relationship between attitudes and behaviour determines the extent to which a global learning approach is implemented into primary science teaching. As outlined in Chapter three, attitudes both shape and are shaped by our actions and behaviours. They may be a catalyst or obstruct action at various personal and professional levels. The global learning in primary science attitude survey was developed from a global learning attitudinal survey designed by Bamber et al., (2013), which aimed to measure feelings and beliefs towards global learning. The survey items were adjusted to focus on science education rather than education in general (for example, 'Global learning will add to childrens' learning **of science**) and item weightings remained the same. In discussion with Bamber via email (Appendix XII, p.191), it was decided that the weightings would remain valid.

Measures of attitude were arrived at by inference. As part of a mixed-methods study, this method enabled larger groups to be compared in terms of the strength of their attitude towards global learning in primary science. As discussed by Bamber et al., (2013), the approach followed the method of equal appearing intervals (Thurstone and Chave, 1929) with the aim of comparing separate groups' attitudes towards global learning in primary science. Fourteen statements regarding global learning in primary science ranging from very positive to very negative were given to the respondents who were asked to agree or disagree with each statement (See appendix III, p.177).

A value of how positive respondents were towards global learning in primary science education was then calculated. The attitudes of groups of respondents (pre-service teachers, teachers, advisors and heads of science) were then compared using PRISM statistical data package. The Analysis of variance (ANOVA) was used to check variances across groups all stakeholder groups, and post-hoc analysis was used to identify any significant difference between groups. Chi-squared tests were also conducted to compare stakeholder attitudes towards individual items, comparing those that agreed with a statement versus those who did not, ensuring that any difference between groups was statistically significant.

5.4.14 Semi-structured interviews

The comparisons of attitudes towards global learning in primary science between each stakeholder group were then developed further through semi-structured interviews with an aim of exploring reasons for different attitudes. In keeping with a social constructivist epistemology, interviews provided an

opportunity for the respondents to share their 'viewpoints about the situation under investigation' (Cresswell, 2017:8), in this case, the opportunities related to global learning in primary science education. The aim of each interview was to extrapolate how individuals made sense of global learning and primary science in relation to their personal belief system and their role. Semi-structured interviews, as advocated by Husband (2020), provided the opportunities for co-construction of understandings between the researcher and respondent during the interview itself about global learning in primary science. Gomm (2004) agreed with the advantage of the cooperative nature of semi-structured interviews. Further to this, Newton (2010: 6) went on to state that semi-structured interviews 'provide rich, original voices' giving them an invaluable quality, enabling more flexibility in obtaining different stakeholders perspectives. Patton (2002) warned, however, that flexibility may result in themes unintentionally being missed, reducing comparability between respondents. It was, therefore, imperative to use guiding interview questions (see appendix XIV, p194) to ensure the research themes are covered, but flexibility to allow for new themes to arise.

Interviews were arranged using the email addresses of those who gave permission to partake in further aspects of the study after completing the initial global learning in primary science survey. Interviews took place either face-to-face in the respondents' workplace (N=15) or over the phone due to distance away from each other (N=15), unfortunately Zoom was not widespread practice at the time of the study, ensuring it was most convenient for the respondent. Unfortunately, video conference calling was not widely used at the time of the research. Whilst some argue that face-to-face is advantageous over phone conversations for semi-structured interviews due to the human contact (Legard et al, 2003), research by Vogi (2013) showed little difference between the two modes of interview. On average, interviews lasted thirty minutes and were transcribed word for word from a recording, omitting communications, such as um and ah (Table 5.5 below for guiding interview questions).

Initially, some pilot questionnaires were undertaken with colleagues to ask them to explain what they thought questions were asking of them, and to refine interviewer skills, as Bowden (2005:19) suggests. The same general areas were covered, and most questions remained the same. However, in reflection to the responses of colleagues to the pilot interviews, it was evident that the phrasing of the questions would be dependent on the stakeholder's role. That said, the questions were organised around three general themes, as highlighted in Table 5.5. These were: the purpose of primary science education, beliefs and attitudes around global learning in primary science education, and challenges and opportunities towards integration of a global dimension both in relation to support, responsibility and resources. These themes were significant in relation to exploring the reasons for responses from the attitudinal survey, as well as answering specific research questions.

Table 5.5 A table of guiding semi-structured questions

Question	Theme	Notes
What is your role?		

What do you enjoy most about science education / teaching science?	Purpose of primary science	
Personally, what do you think should be the main purpose of primary science education?		
What values/ attitudes do you think children should develop through their science education?		
To what extent do you think the current National Curriculum programmes of study enable teachers to fulfil these aims and develop these values?		
What do you understand by the term global learning?	Attitudes and understanding of global learning in relation to primary science?	
Do you think it is relevant to primary science education? How? Why?		
Do you think teachers should be responsible to keep informed about developments in science around the world? How?		
In what ways do you think trainee teachers and teachers should be supported to deliver a science curriculum fit for purpose?	Opportunities and ways in which teachers can be supported to integrate global learning in primary science	
What resources / platforms do you use to keep informed about changes in science in the real world?		
What resources / initiatives do you use to keep children informed about global issues (both generally and in science)?		

5.5 Data Analysis

Interviews were transcribed by the researcher mainly word for word. However, vague comments, such as “umm” and “I think” were deleted if they did not contribute meaning to the data. This enabled coding through NVivo to be more efficient.

As advocated by Braun and Clarke (2006), familiarising oneself with the data from semi-structured interviews was essential. As pointed out (Braun and Clarke, 2006:80), ‘what is important is that the theoretical framework and methods match what the research wanted to know’. During the transcription, therefore, the researcher developed a personal profile for each transcript to gain an overview of their

motivations, beliefs and concerns around primary science education. Galletta (2012) recommended that an ongoing and iterative process is necessary to ensure meaning is direct from the data. Resultantly, a continual loop back to the individual profiles was important so that the data could be more deeply understood. Asking the reflective question, 'what is the person trying to say?' was used with the aim of helping to develop an understanding of how each individual participant perceived the idea of global learning in relation to their role and to primary science. By drawing upon individual profiles for each participant, it also helped to ensure trustworthiness of the research (Lincoln and Guba, 1985), which can be summarised in table 5.6. Individual profiles helped maintain internal validity (credibility) by aiming to preserve the meaning intended behind all the quotes in the context of their own interview.

Table 5.6 A Summary of trustworthiness, in relation to Lincoln and Guba's four-dimension criteria to assess the rigour of the study (Lincoln and Guba, 1985).

Rigour Criteria	Purpose	Strategies in the research to achieve rigour
Credibility	To establish confidence that the results (from the perspective of the participants) are true, credible and believable	Pilot semi-structured interviews to ensure that questions were focused on research aims. Training to ensure the interviewing process was rigorous and enabled respondents to elaborate on their responses. Creation of individual profiles to develop an overview of each respondent.
Dependability	To ensure the findings of this study are repeatable if the inquiry occurred within the same cohort of participants, coders and context.	I developed a detailed track record of the data collection process, including times, locations, and guiding questions. I used a reflective diary to ensure reflexivity after interviews and all aspects of the research I measured accuracy through the support of respondents by confirming that transcriptions were a reliable reflection of interview
Confirmability	To extend the confidence that the results would be confirmed or corroborated by other researchers.	Interviews were triangulated with the reflective diary, the quantitative data and evidence from case study schools
Transferability	To extend the degree to which the results can be generalised or transferred to other contexts or settings.	Purposive sampling was used, and description of each interviewee was created

As Rubin and Rubin (1995) acknowledge, data analysis enables themes and concepts to be discovered from interview data. However, it was important to acknowledge the active role the researcher played in identifying patterns and themes which related to the theoretical framework of the research (Taylor and Ussher, 2001). Thus, whilst being flexible in data analysis, it was important to acknowledge researcher values and theoretical positions (thus using pre-identified themes). That said, patterns within the data (themes and stories) were analysed from the transcriptions, along with workshop evaluation feedback, reflective diaries, with the use of NVivo software, to ensure confirmability of the data. Participants' responses on related topics were grouped together into nodes of meaning.

This research was designed to explore the extent to which and ways in which global learning as a pedagogical approach could raise the profile of science in primary education. As a result, the following areas were analysed in relation to the research questions: teachers' beliefs, teachers as agents of change, PCK and approaches to professional development.

Exploring the responses of each sample group, the analysis aimed to appreciate each role in relation to science teaching and learning and their subsequent influence on its development. The data sources of the quantitative survey, interviews and reflections were used in combination to highlight any patterns in relation to the research aims. Interviews, for example, were used to explore the quantitative data from the survey. However, for each of the areas of analysis, some sources of data were more useful than others. For example, samples of work and interviews were more useful than surveys for exploring science pedagogy. The section below will outline the data analysis procedures.

5.5.1 Developing analysis schemas

Remaining true to a social constructivist epistemology with an element of pragmatism, thematic analysis was used for analysing data. Thematic analysis is the most widely used qualitative approach to analysing interviews. As discussed by Braun and Clarke, (2006), this approach to analysing data provided a rich and detailed, yet complex account of the data. In this study, to answer the research question, it considered a range of stakeholders' views and experiences in relation to primary science and global learning aiming to elicit the ways and extent to which global learning is both relevant and valuable to its development.

Thematic analysis can be described as a method for identifying, analysing, organising, describing, and reporting themes found within a data set (Braun and Clarke, 2006). Boyatzis (1998) supports the idea that thematic analysis enables different research methods to 'talk to each other'. While thematic analysis is flexible, Holloway and Todres (2003) warn that this flexibility can lead to inconsistency and a lack of coherence when developing themes. Consistency and cohesion were established by focusing on the research questions, and establishing trustworthiness by introducing the criteria of credibility, transferability, dependability, and confirmability, as advocated by Nowell and Norris (2017) and outlined using Lincoln and Guba's four-dimension criteria in Table 5.4 on page 70.

An important consideration was identifying the themes in the interview data collected (that is, key ideas about the data in relation to the research questions). It was important to identify themes influenced by the theoretical framework. Data collected through interviews with different stakeholders were therefore analysed by a three-stage process suggested in literature (Creswell, 2007): preparing the data for analysis by transcribing, reducing the data into themes through a process of coding, and representing the data with the use of NVivo software.

5.5.2 Analysing teacher attitudes and beliefs towards global learning in primary science

In relation to the discussion in Chapter three on teacher beliefs and attitudes, it was evident that beliefs and attitudes have a significant impact on teacher actions (OECD, 2009). Within this study, the importance of attitudes towards global learning within primary science was considered in relation to decisions and changes in pedagogical practice and lesson planning (as highlighted by Pajares, 1992).

At a micro level, the first research question stated: How do stakeholder beliefs, attitudes and a sense of agency related to global learning in primary science impact on their engagement with the approach? Resultantly, it was necessary to identify beliefs towards global learning in primary science, considering the potential for related strategies and pedagogy to be integrated into its delivery.

Identifying beliefs and attitudes is acknowledged to be difficult for many reasons, as discussed in Chapter three (Pajares, 1992). Within this research, primary teachers' beliefs and attitudes towards global learning in primary science and related professional development were considered central to any impact. However, as discussed above, using social constructivism meant that other emergent themes from interacting with respondents were relevant and discussed in relation to the overarching research question.

To develop a rich understanding of beliefs towards global learning in primary science, the range of data sources discussed above were analysed together. Areas related to beliefs were separated into the following themes through the NVivo analysis: beliefs related to the purpose of primary science education, beliefs related to the teacher's role in its delivery, beliefs related to the role of global learning, and beliefs related to attitudes and values developed in primary science. It was, however, important to acknowledge that these categories were overlapping.

The resulting analysis informed the findings in the next chapter, comparing beliefs of different stakeholders and those who had and had not participated in the global learning in primary science workshops. As one of the overarching aims of the project was to challenge beliefs and consider the potential for a change in pedagogical approach to primary science, those who participated in the workshops were compared.

5.5.3 Analysis of teachers as agents of change

As well as considering beliefs, Chapter three discussed the importance of supporting practitioners as agents of change, considering agency as something people achieve rather than something people have, (Priestley, 2015). To determine the impact of the global learning in primary science professional development on practitioners as agents of change, it was important to consider what support and resources stakeholders identified as valuable to scaffold a global learning approach to primary science. Three case study schools were explored in more depth, along with the researcher's reflective diary and evaluation feedback from workshops. Developing an understanding of how practitioners implemented aspects of the approach in their subsequent practice was used to provide evidence of impact on teachers as change agents.

5.5.4 Analysis of changing practice and impact of empirical research of this study

Research question two aimed to consider the strategies and approaches of professional development and ITE that would support a global learning in primary science approach. In relation to the theoretical framework, the aim was to explore aspects that may be significant in enabling practitioners and stakeholders to reflect on their beliefs, attitudes and pedagogical approach to primary science.

All data sources were used to respond to this research question. For example, the semi-structured interview questions which elicited data related to the impact of the global learning in primary science approach included:

- What strategies have you implemented into your practice (if any)?
- What challenges have you found in the integration of global learning into your practice?
- What additional resources / support would be useful?

The following survey items were also related to this research question:

- Incorporating global learning is beyond the role/scope of being a teacher
- I hate the whole idea of teaching about global learning into science
- Whilst global perspectives in learning could be important, the concept may need further clarification to be usefully applied to the science curriculum

And finally, asking teachers and schools for any other evidence of implementation of a global learning approach was used in the data analysis to consider the ways and extent to which global learning could be integrated into primary science.

5.6 The role of the researcher

This study aimed to gain an insiders' perspective on the unexplored area of global learning as an approach to primary science education. As a dynamic process, I took an active role, acknowledging my

own experiences and ideas. As Creswell (2013) acknowledges, there is a close link between our personal philosophy and our research approach. It was, therefore, imperative that personal values, assumptions and biases were identified from the beginning of the research. Reflexivity, as previously discussed, involves an exploration of 'how a researchers' involvement with a particular study influenced, acted upon and informed the research' (Nightingale and Cromby, 1999:228), advocated by Meyrick (2006) who suggests that it supports more objective data collection.

In accordance with Lincoln and Guba (2000), a personal interrogation promoted rigour within my data collection. I have worked as an educator for over 16 years, in England, Japan and The Gambia, in the capacity of a teacher, science-subject lead, senior leadership team member, teacher educator and professional development advisor. This enabled me to discuss different perspectives with some 'authority' having insider knowledge of these roles (Crossley and Watson, 2003:26). During my work as a teacher educator, working closely as a mentor for both students and teachers allowed me to see from different perspectives and enabled me to consider the motivations, challenges and responsibilities in relation to primary science education.

Although this study did not solely take a case study format, following how three case study schools and teachers used the global learning in primary science approach was an important aspect of data collection to answer the research questions of this study. This study spanned over a year, and whilst important to explore influences of the global learning in primary science workshops, as Stake (2010) asserts, it was important not to be confined by time boundaries. For example, what happens before and after the study is often of significant importance, and this is noteworthy in terms of the status of primary science education in the political agenda, and respondent experience. Within my position as a consultant and lecturer in primary science, it was important to be continually aware of the changing landscape of initiatives, frameworks and policies which impact on primary science education.

5.7 Ethical considerations

For this thesis, in terms of integrity, an understanding of 'trustworthiness' as a measure of validity (Bassey, 1999) was underpinned by the data collection, analysis and conclusions drawn in relation to global learning in primary science education. As Lincoln and Guba (1985: 290) state, trustworthiness ensures that any findings are 'worth paying attention to'. It was important that the respondents were made aware of the aims of the research, as well as the confidentiality and anonymity of any responses, as advocated by Cohen et al (2018). Through an information sheet and permission sheet, respondents were, therefore, made aware that their names and schools would remain anonymous throughout the research, and that all data would be stored securely throughout and beyond the research project. Voluntary written consent was verified at the start of each interview (appendix XVI, p.200). To respect all participants within my professional community of practice, anonymity and confidentiality of all respondents was carefully safeguarded through labelling them as a number, for

example. head of science 1, and transcripts were saved in password protected files on the university's secure computer network as guided by BERA (2018).

Approval was requested and obtained to conduct the project from the University Ethics committee, adhering to BERA (2018) and University ethical guidelines. All respondents were given an information statement and gave consent prior to their interviews. They were informed of their right to withdraw or refuse to answer questions at any point during the study, ensuring participants had contact details to withdraw or ask questions at any point. By giving all respondents a number, it would be easy to identify and exclude their data at any point.

5.8 Chapter summary

This chapter described the study's methodology and the methods used to collect and analyse the data to address the research questions. To provide different perspectives, different stakeholder viewpoints were collected using a range of data sources to explore beliefs, professional development strategies and integration of a global learning approach to primary science. The attitudinal survey, semi-structured interviews, schemes of work and children's work were successfully sourced along with my own reflective diary to ensure researcher reflexivity throughout the research. Whilst it may be useful to do so in future research, the attitudinal survey was only conducted at the start of the research, limiting the ability to explore the impact of the professional development workshops, something that may be useful in future studies.

Through analysis of the data, the four research areas were addressed: teachers' beliefs and attitudes towards primary science and global learning, teachers as agents of change, professional development and pedagogical change. Despite ensuring that data analysis was approached with openness to emerging themes, it was acknowledged that the research literature, as well as the global learning in primary science professional development, structured the data analysis.

CHAPTER 6 A PRESENTATION AND ANALYSIS OF RESEARCH FINDINGS RELATED TO GLOBAL LEARNING IN PRIMARY SCIENCE

6.1 Introduction

This chapter will provide a presentation and analysis of findings related to beliefs, attitudes and professional learning related to global learning in primary science. Creswell and Plano Clark (2011) highlight that a mixed methods approach enables a greater degree of understanding to be formulated than if a single approach were adopted. For this reason, as explained in Chapter five, the quantitative survey was conducted with six stakeholder groups (primary science advisors, primary school senior leadership, heads of primary science, teachers and pre-service teachers) each with 30 respondents (150 in total), in conjunction with semi-structured interviews with five individuals from each group (25 in total). The interviews offered insight into the patterns highlighted in the surveys.

This chapter considers the perspectives and beliefs of five different groups of people who have an influence on the content and delivery of primary science education. Within this population, some individuals had participated in the global learning in primary science professional development, whilst others had not. This provides an additional layer to the data analysis, considering how the professional development input influences primary science practice, and what influences engagement with it, in a primary science approach.

Chapter five set out the areas that were the focus of this study: beliefs towards global learning in primary science education, supporting teachers as agents of change, and the influence of the global learning in primary science approach. These research areas will structure the presentation of findings and analysis.

Although the study was carried out over a year period, data was collected throughout the project, with reflexive changes and developments to research design and project resources. As a result, while the influence of the approach will be discussed further in Chapter seven, the focus of this chapter will be on the relationships between beliefs and attitudes and motivation to integrate a global learning approach to primary science. Further to this, when considering implementation of the approach in Chapter seven, the principles of global learning in primary science pedagogical framework are discussed.

Whilst grouping individuals in each category to share findings, it was important to remember that categories overlap, and individual responses differ greatly due to their backgrounds, experience, professional contexts and other responsibilities, as identified in chapter 3 (Woolfolk Hoy, Davis and Pape, 2006). It was also important to consider that those who volunteered to participate in the global learning in primary science workshops potentially had an existing positive attitude towards or interest in global learning. To retain the individuality of each perspective, a summary of each interview

was created (see appendix XVI, p.199). This table presents the complexity of introducing a new approach, when each respondent has a different perspective in relation to their beliefs, vision, context and identity in relation to primary science education, as recognised by Fairbank, Duffy and Faircloth, (2009). For example, whilst advisor 1 was a PSQM hub leader and PSTT fellow, they were also a class teacher, thus having a unique identity and perspective. Finally, in order to have a deeper understanding of the findings related to each case study school, a summary table introduces the profile of each school and their engagement with the global learning approach (Table 6.1, found below).

6.1.1 Case Study Schools

Whilst all schools were similar in terms of population and type, as described in the case study school profiles (Table 6.1) their management and leadership of science and its stage of development were very different. The findings in this chapter aimed to highlight how and why practitioners may respond to, and engage with, a global learning approach to primary science in different ways. For example, school A was conducting a primary science quality mark application (PSQM), suggesting that they valued the development of quality science within their school.

Table 6.1 Profiles of the Case Study Schools

	School A	School B	School C
Type	Community	Community	Community
Gender	Mixed	Mixed	Mixed
Population	249	568	478
EAL	37.3	36.4	8.8
Values / ethos	'We dream big' Motto: 'Work hard Be Kind' Learn, love, live	Ambitious, self-aware, persevering, inclusive, respectful and empowering	Innovate, nurture, inspire, fly
Science Initiatives	Conducting Primary Science Quality Mark	None (Previous PSTT fellow but none at present)	None
Initial Global Learning in Primary Science Workshops	Whole school staff including head teacher, deputy head and teaching assistants	Whole school staff team excluding senior leadership team	Head of science and teachers who are responsible for delivering the science curriculum
Planning Model	Senior leadership team and head of science introduced planning template which was adopted by all staff Each class was given sustainable development goals to explore and present as part of a themed week.	Head of Science added an additional column onto science planning template Whole school science week with a Global Learning lens	Head of science was given planning time with science team to collaborate and developed global learning themes for science schemes of work
Reflective interviews	Head teacher and head of science	Head of science	Head of science

6.2 Beliefs, teachers as agents of change and pedagogical practice

6.2.1 Relationships between beliefs, agency and a global learning approach

This section presents the findings in relation to stakeholders' beliefs, attitudes and agency within their roles related to teaching science in the primary classroom. In Chapter three, beliefs and agency were identified as fundamental in determining how, if at all, teachers used global learning in their pedagogical approach. With an understanding from teacher professional development research that there is a strong relationship between teachers' beliefs and their practice (Borg, 2011; Wallace, 2014), the findings in this chapter elicit teachers' beliefs toward both science and global learning.

Through synthesising data from the attitudinal surveys, the semi-structured interviews and my own reflective diary, this chapter presents themes that have emerged related to beliefs and teacher agency. The chapter will then go on to explore a relationship between attitudes and pedagogical practice.

6.2.2 Stakeholder beliefs about the purpose of primary science education

Whilst changes in beliefs may be fundamental to pedagogical choices (Prestidge, 2012), they are not the only factors to consider (Assen, 2016). Some argue that outcomes of practice can influence beliefs (Desimone, 2009), whereas others argue that teacher beliefs must align with that of the person sharing the professional development or new approach (Ertmer, 2012). The global learning in primary science workshops commenced with activities which enabled respondents the opportunity to discuss and identify beliefs about primary science education. Through working collaboratively and writing down words and phrases conveying their beliefs about the aims of primary science education, respondents created word clouds, as shown in Appendix XXV, p.208. The words and phrases from these activities were then tallied against the aims of the global learning approach to primary science approach.

The respondents were given the opportunity to identify the parallels between their own ideas and the global learning in science approach. Whilst this was a rudimentary method, as identified in my reflective diary (Reflective diary, appendix XVI, p. 209), giving respondents the opportunity to see both similarities and differences in their perspectives regarding the aims of primary science with those of a global learning approach was a beneficial exercise to enable participants to reflect on their beliefs regarding the aims of primary science education and align them with a global learning approach.

Appendix XIX, on page.203, outlines how identified aims of primary science overlap with the aims of the global learning approach. The findings in this table demonstrate that other than exploring and making sense of big issues in science, and arguing a position or view, all other aspects of a global learning perspective in primary science were stated as being important aims of primary science education. Unsurprisingly (being explicit in the National Curriculum in England (DfE, 2013), 30 out of 40 workshop respondents mentioned that being active participants in science enquiry was an important aspect of

primary science. Highlighting how the global learning approach complements scientific enquiry in primary science is important to empower and engage practitioners. As Fairbanks (2009) agrees, encouraging teachers to examine overlapping knowledge, theories and beliefs are an important aspect of effective professional development.

Notably, several respondents from the workshops shared the belief that primary science education should support children to reflect on the consequences of their own actions (n=16) and should enable them to take responsible action (n=14). Referring to the National Curriculum programmes of study aim, 'to understand the uses and implications of science, today and for the future', (DfE, 2013), these beliefs relate to this. It could be argued, however, that reflecting on the consequences of their own actions and taking responsible action goes beyond 'understanding' and requires the ability and motivation to apply this understanding. Demonstrating how the global learning approach can operationalise the third aim of the National Curriculum in England, however, was powerful in the instigation of further engagement, as advocated by Hargreave's (2009), highlighting the importance of taking account of the alignment with different levels of a system. This was evident in my reflective diary in Appendix XVIII, p.202 which highlighted that SLT members recognised the opportunity to use the global learning approach to fulfil the third aim of the science National Curriculum, that being to equip learners with 'the scientific knowledge required to understand the uses and implications of science, today and for the future' (DfE, 2013: p. 3).

Acknowledging the importance of developing, as well as eliciting, shared beliefs amongst stakeholders in the incorporation and embedding of a pedagogical approach (Adey, 2004: 153; Clark and Hollingsworth, 2002; Guskey, 2000; Biccard, 2019) was evident within both my reflective diary (Appendix XVIII, p.202) and the reflective interviews with stakeholder schools (Appendix XXVI, p.209). As discussed in section 6.3 this was found to be true with the case study schools who proceeded with the approach. Considering aims of top performing country science curricula (DfE, 2015; 2019) and selecting aspects which resonated with respondents was also identified as a beneficial activity of the project helping respondents to see beyond their own country's curriculum aims:

'I suppose I took for granted that science wasn't the same in different countries. It was exciting to see different ways other countries approached science' (Case Study School C: Interview with head of science, Appendix XI, p. 187).

As a reflective interview highlighted, the process of drawing on similarities between other country science aims and their own, helped to nurture a global attitude towards science education. As identified by Oates (2010), a curriculum cannot be replicated, but it can be learned from:

'Although we know it is important to ensure we are covering the programmes of study [of England, DfE, 2013] reading the aims of other country curricula inspired us to consider wider aims in developing global citizens' (Case Study School C: reflective interview with head of science, Appendix XI, p.187).

The SDG 4.7 (UNESCO, 2015a) indicates the aim of all learners acquiring the knowledge and skills needed to promote sustainable development. Research by Walhstrom (2018) based on international analyses of curricula demonstrated that there is substantial agreement across nations that teaching content should contribute to shaping autonomous citizens, linking countries through global development. However, as these findings reveal, global development as an aspect of science aims is more explicit in some than others, for example, Scotland's curriculum for excellence (Education Scotland, 2016a) which states that children should 'recognise the impact the sciences make on their lives, the lives of others, the environment and on society, develop an understanding of the Earth's resources and the need for responsible use of them, and express opinions and make decisions on social, moral, ethical, economic and environmental issues based upon sound understanding' (Education Scotland, 2016a: p.2). As Walhstrom (2018) acknowledged, comparative studies have been increasingly important both for policy formulation and research. Whilst borrowing of policy is selective and hard to translate, and risks teachers being caught in a dilemma between a shared vision of science education and growing centralised control, as Ryder (2017) recognised, gaining ideas from other national policy has been reported to give teachers an opportunity to refocus their understanding of standards.

My own reflective diary (Appendix XVIII, p. 203) also identified that respondents articulated that they were both 'relieved and reassured by the outline of a global learning approach to primary science' (Appendix XVIII p.203) as they were practicing many of the aspects already (such as enquiry, communicating evidence, listening to each other's perspectives). Drawing parallels between their beliefs about the purpose of primary science education and a global learning approach may be essential in underscoring that the approach is not about squeezing more into an already packed curriculum. The findings comparing beliefs towards global learning in science and science in general are outlined below to consider how, and if, these could be used to underpin or initiate a change in approach.

6.2.3 Stakeholder beliefs concerning global learning in primary science

Appendix XX, p. 203 shares the summary data of the responses from the attitudinal survey, sharing the frequency of agreements to each statement relating to global learning in primary science, which revealed that all stakeholder groups had positive attitudes towards global learning in primary science, (a value of more than four being positive).

Advisors	SLT	HOD	Teacher	Pre-service teacher
5.212	5.69	5.763	5.584	5.767

Appendix XXI and appendix XXII in the appendices on page 207 that proceed to share a statistical analysis of the results to highlight findings related to the overall attitude towards global learning in primary science as well as a comparison between the key stakeholder groups. This identified a statistically significant difference between the attitudes of advisors when compared to each of the other

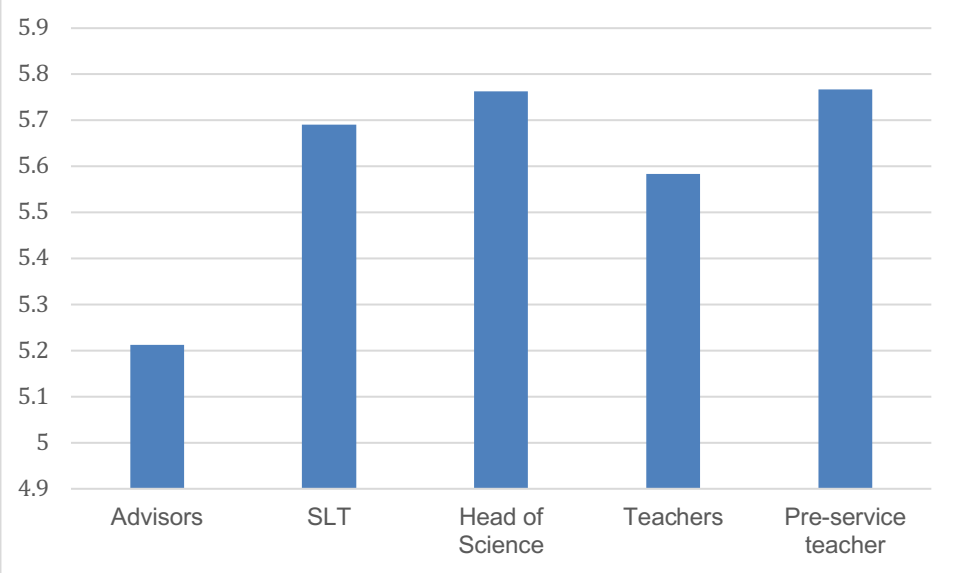
stakeholder groups, that is, the attitudes towards global learning of the advisor group were significantly less positive toward global learning than that of the other stakeholder groups, with a mean attitudinal score of 5.212:

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
Advisors vs. Pre-service Teachers	-0.5549	-0.9265 to -0.1834	Yes	***	0.0004
Advisors vs. Heads of science	-0.5510	-0.9225 to -0.1794	Yes	***	0.0004
Advisors vs. Teachers	-0.3721	-0.7437 to -0.0004940	Yes	*	0.0495
Advisors vs. SLT	-0.4820	-0.8536 to -0.1104	Yes	**	0.0034

Figure 6.1 below summarises stakeholders' initial attitudes toward global learning in primary science during initial workshops. It shows that all stakeholders are generally positive towards global learning in primary science from the outset (with a mean score of 5.692). The responses related to beliefs regarding global learning in primary science were obtained before any workshops were undertaken, but all respondents were given a brief outline of the global learning in primary science approach as well as having an opportunity to visit the dedicated website (https://globalprimaryscience.squarespace.com/) which outlined how global learning related to programmes of study in the primary science National curriculum in England (DfE, 2013).

Figure 6.1 A Chart to compare beliefs toward global learning in primary science of different stakeholder groups.

(A scale from 1 – 7, more than 4 being positive)



To consider reasons for stakeholder attitudes, and to explain the variations in positivity towards the approach, Table 6.2 compares beliefs towards global learning in primary science of five different groups alongside related comments from the semi-structured interviews of the different stakeholders.

Table 6.2 Attitudes towards global learning in primary science

Stakeholder	Attitude Value	Semi-structured interview comments related to attitudes / beliefs towards global learning in primary science	Indicated interest in further GL in primary science workshops / CPD.
Advisors	5.212	1) Creates a shared understanding and sense of community Allows children to access their science learning Makes children feel valued and have a purpose Makes teaching more enjoyable Motivating factor 2) Holistic approach to the curriculum Curiosity about the world around them Transferrable skills Problem-solving Positive impact 3) Understanding the impact of science on the real world 4) Global dimensions in science give teachers a sense of purpose / ownership of the delivery of the curriculum. Whilst sustainable issues are important, without good subject knowledge, it will be hard for teachers to make the links 5) Important and integral but SDGs are not turned into an educational framework so they are hard for teachers to interpret.	Yes Yes No No Yes
Senior Leadership team	5.694	1) Real life application Realistic, practical, memorable 2) Develops critical thinking 3) Engaging, interesting, fun 4) Global learning should be an essential aspect of planning, should be an expectation 5) Purpose beyond the facts 6) Creative and memorable 7) Important to us as a school to give knowledge a purpose	No No No No Yes No yes
Head of science	5.763	1) Makes learning more purposeful and personal Develops attitudes towards our planet and how to look after it Dedicated to global goals	Yes Yes

		2) Important dimension to make the science learning interesting 3) Children to enjoy learning about the world around them 4) It makes science more meaningful 5) Important but potentially too challenging for the average teacher	 Yes No No
Teacher	5.584	1) Understand the world around them how the world works 2) Important for science careers Foster an interest in how the world works 3) Make science more cross-curricular 4) Current relevance of global learning to help children realise that they can do something to stop things like climate change	Yes No (time) Yes Yes
Pre-service teacher	5.767	1) Interesting hooks, themes to plan learning around; 2) Nurtures appreciation of wider world – missing puzzle piece; 3) Helps them to respect and understand the world. 4) Interesting and engaging and will engage learning of the curriculum 5) Useful to support more creative science teaching	Yes Yes Yes Yes Yes

These findings identify that advisors in the semi-structured interview sample believed that global learning in science would only be successful with confident underpinning subject knowledge, and therefore may detract from the focus of securing core knowledge and skills. For example, one respondent stated:

> '*Whilst sustainable issues are important, without good subject knowledge, it will be hard for teachers to make the links'* (Advisor 4, table 6.2, p.82).

Further to this, discussion with primary science advisors during an Association of Science Education conference indicated the same concern:

'*Time is so limited; I don't know if teachers have the confidence with their science subject knowledge or sustainable development goals to teach them together simultaneously'* (ASE reflective diary: 09.01.20, Appendix XVII, p.201).

Semi-structured interviews revealed that most respondents' beliefs about the potential benefits of global learning in primary science were related to attitude development and engagement (using words such as 'enjoyable, motivating, interesting, purposeful' rather than knowledge and skill development as

presented in Appendix XXIV, p. 207). Phrases such as ‘fosters an interest’, ‘brings relevance’ and helps children have an ‘appreciation of the wider world’ appear across more than one stakeholder group. These findings reflect the positive attitudes found in the survey, suggesting that stakeholders see the potential benefits of a global learning approach in bringing relevance to the science curriculum they deliver. Two respondents (both teachers) also highlighted the potential for the approach to make science more enjoyable to teach and will support creative planning. The discussion chapter will, therefore, consider the importance of the global learning in primary science approach not only to support engagement in learning, but also support greater investment and engagement in teaching.

Mansour (2013) identified that practitioners do not accept innovative ideas in professional development unless they have been informed about their effectiveness. This provided a potential reason for the disparity between positive attitudes to global learning in primary science and the motivation to pursue further professional learning in the area, especially in a climate of limited time for professional development matched with a focus on accountability measures. As the findings in table 6.3 below show, despite an overarching positive attitude towards the global learning approach in primary science education, some stakeholders did not indicate interest in the pursuit of further professional development. SLT, for example, only had 50% of respondents from the survey and 40% of respondents from the semi-structured survey who indicated that they would be interested in further global learning in primary science professional development.

Table 6.3 A comparison of attitude to a global learning approach to primary science and the desire to pursue further related professional learning

Stakeholder group	**Attitudinal value**	**Frequency of respondents from attitudinal survey who indicated interest in further global learning in science workshops / CPD.**	**Frequency of respondents from semi-structured interviews who indicated interest in further global learning in science workshops / CPD.**
Advisors	5.212	8 (27%)	3 (60%)
SLT	5.694	15 (50%)	2 (40%)
HOD	5.763	21 (70%)	3 (60%)
Teacher	5.584	9 (30%)	3 (60%)
Pre-service teachers	5.767	25 (83%)	5 (100%)

The findings here also demonstrate that pre-service teachers have the highest percentage of respondents indicating interest in pursuing further professional learning related to global learning in primary science. This is consistent with the idea that constraints such as accountability, timetabling and

emphasis on English and maths deter engagement (Grice, 2019), as this stakeholder group is not yet working within a school system, and therefore liberated from these constraints, perhaps not yet disillusioned, or perhaps viewing the approach from an idealistic perspective.

Whilst having a positive attitude towards a new approach is an important factor influencing change in pedagogical practice, there are many other constraints and factors to consider. In general, the stakeholders that indicated interest in further global learning in primary science CPD valued the approach for the potential opportunities to contextualise scientific skills and knowledge. Thirteen out of eighteen of such respondents used the words 'relevant' or 'purpose', for example:

> *'Nurtures appreciation of wider world – missing piece of the puzzle to help them [the children] see the purpose of what they are learning'* (Pre-service teacher 2, semi-structured interview, Table 6.2, p.83).

This aligns with recent research conducted by Bianchi et al (2021) which highlights that a key issue with children's learning in primary science in England is enquiry work that lacks purpose. It was, therefore, important to explore teacher attitudes towards the purpose of primary science education and how these aligned with a global learning approach.

6.2.4 Outcomes of primary science education

Beliefs relating to the purpose of science learning have emerged as an important influence on teachers' engagement within the study. Data from the interviews suggests that there is a relationship between respondents' beliefs related to the purpose of science learning and motivation toward the global learning approach. When categorising responses concerning the purpose of primary science as either to gain knowledge (disciplinary, interdisciplinary, epistemic and procedural), skills (cognitive, social, emotional and practical) or attitudes and values (personal, local, societal and global) according to the definitions from the OECD Framework 2030 (OECD, 2018a), it was evident that those stakeholder groups who emphasised the importance of attitudes and values had a greater positive attitude value towards the global learning in primary science approach and had a greater frequency who indicated further interest, as illustrated in Appendix XXII, p. 208. For example, the two advisors that indicated interest in pursuing further professional development in the global learning approach highlighted how science education should support children to 'explain how they [the children] can positively impact on the world they live in and understand why their own actions are important.

The data in the table shows that advisors and senior leaders value the importance of foundational knowledge and skills which align closely to the National Curriculum, DfE (2013: 3):

- develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics

- develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them.

Along with advisors and SLT, heads of science also identify the importance of preparing future scientists, for example:

> *'Science in primary should develop the skills children need for future careers in science, especially more modern skills such as data handling' (Advisor response, Appendix XXIV, p. 206).*

Teachers and pre-service teachers' responses seemed to focus more on helping children to become more independent in their scientific thinking:

> 'It should teach children how to ask a question and find out the answer in a systematic way (teacher 5, appendix XXIV, pg. 206).

Especially in relation to this study, it was evident that aside from five respondents (identified in the attitudes and values column of appendix XXIV, p.206), respondents did not convey a transformative view of science learning, as discussed in section 3.4.1. Whilst this suggests the requirement of a paradigm shift for the success of this approach, considering how the global learning pedagogical approach could support the development of science knowledge and skills should also be considered. The acknowledgement of Wynne Harlen's 'big ideas' which relate to the important foundational science knowledge (Harlen, 2010) in Appendix XXIV, p.206, by one of the advisors, provides an important consideration of how big ideas can be related to global issues.

6.2.5 Stakeholder beliefs about the attributes primary science learning should develop

As well as asking stakeholders to articulate their beliefs around the purpose of primary science education during the semi-structured interviews, they were asked which attitudes and values primary science education should develop beyond the working scientifically skills of the curriculum (Appendix XXIV, p.207). Haste (2018) highlights that attitudes and values are integral to the development of knowledge, skills and agency. He goes on to indicate that attitudes and values provide motivation for developing and using knowledge and skills, which consequently act as a cognitive and affective engine for agency. As discussed in Chapter three, attitudes and values can provide a framework for what constitutes global citizenship and agency for change. The OECD (2019a: 10) suggests that to shape the future, young people 'need to be able to use their knowledge, skills, attitudes and values to act in a responsible way'.

When matching the attitudes and values respondents thought primary science education should develop with those identified in a global learner, identified within the global citizenship framework (Oxfam, 2015), many of these overlapped (see Table 6.4 on page 88, below). Out of the thirty respondents interviewed, five respondents highlighted the value of diversity and five highlighted the

value of participation and inclusion. Seven indicated the importance of responsibility and ability to solve problems. As will be discussed further in Chapter 8, these findings demonstrate an opportunity to help practitioners develop these attitudes and values (which underpin a global learning in primary science approach) in primary science teaching and learning. However, as highlighted in the following chapter, unless made explicit within a curriculum framework, I would argue that it needs to be considered whether the development of these attitudes and values may be left to chance. Mansour (2009) reported the importance of a congruence needed between science teachers' beliefs and the underpinning philosophy of any curriculum.

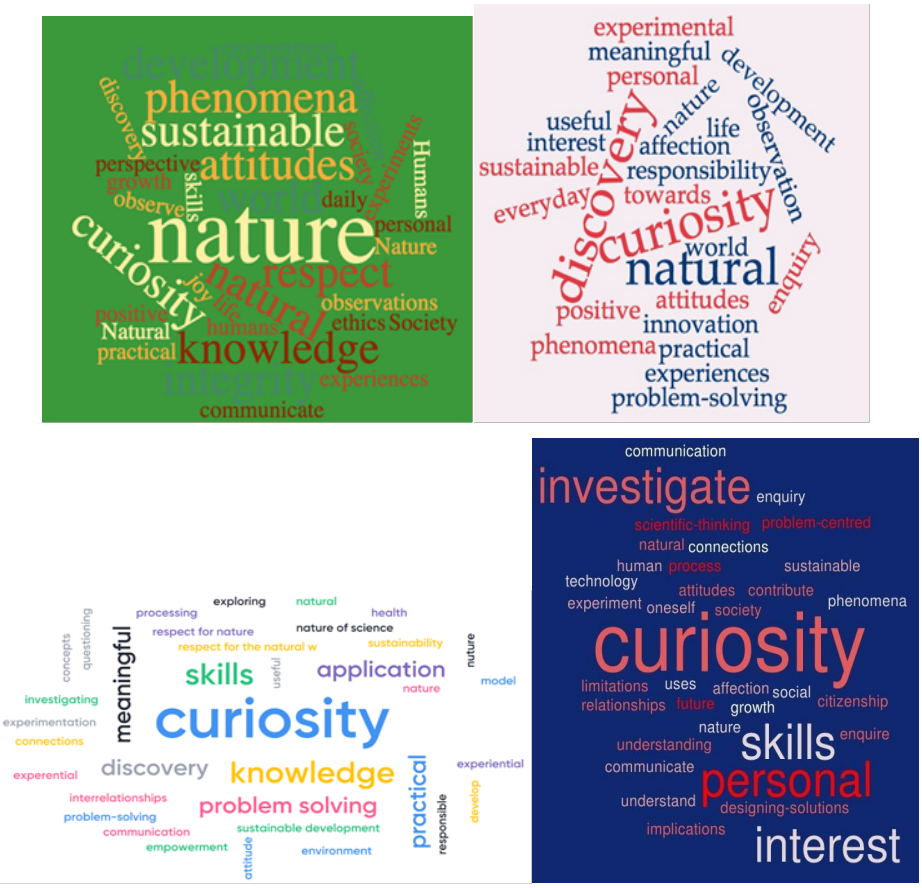
Table 6.4 Frequency of respondents' beliefs relating to attitudes and values matching global citizenship attitudes and values.

Global learner attitudes and values (Oxfam, 2015)	**Frequency within responses**	**Related responses from appendix XXIV**
A sense of identity / self-esteem	4	Feel valued and have a purpose Learn to communicate their ideas with confidence Resilience They need the tools to make informed decisions about themselves
Equity	2	Empathy for other people and circumstances around the world Fairness
Respect	2	Respect of life A respect and understanding of the world around them
Diversity	5	Different perspectives Nurture an appreciation for the wider world and their place in it different approaches and outcomes Share their ideas enjoy learning about the world around them
Sustainability	4	Interdependence Developing their attitude towards our planet and what we need to do to look after it / help save it. They need the tools to make informed decisions about themselves and their environment
Inclusion / participation (e.g. teamwork)	5	Learn to work together Learn how to work as a team Working as a team because discovery Science careers requires collaboration An understanding and working as a team
Agency / responsibility (e.g. problem-solving in relation to local and global issues)	7	Develop positive attitudes to solving problems Ability / responsibility to find solutions to their own and other's problems Problem-solvers and know there are different ways to look at and Solve problems Trial and error Problem-solving skills Innovation Develop problem-solving skills Solve different problems Problem-solving

A similar finding was also shown during the global learning in primary science CPD workshops. During the initial task of looking at the aims of primary science education across the top fifteen performing countries in the world (according to OECD PISA ranking, 2018a) respondents noted down words and phrases that resonated with their own beliefs about primary science education. These

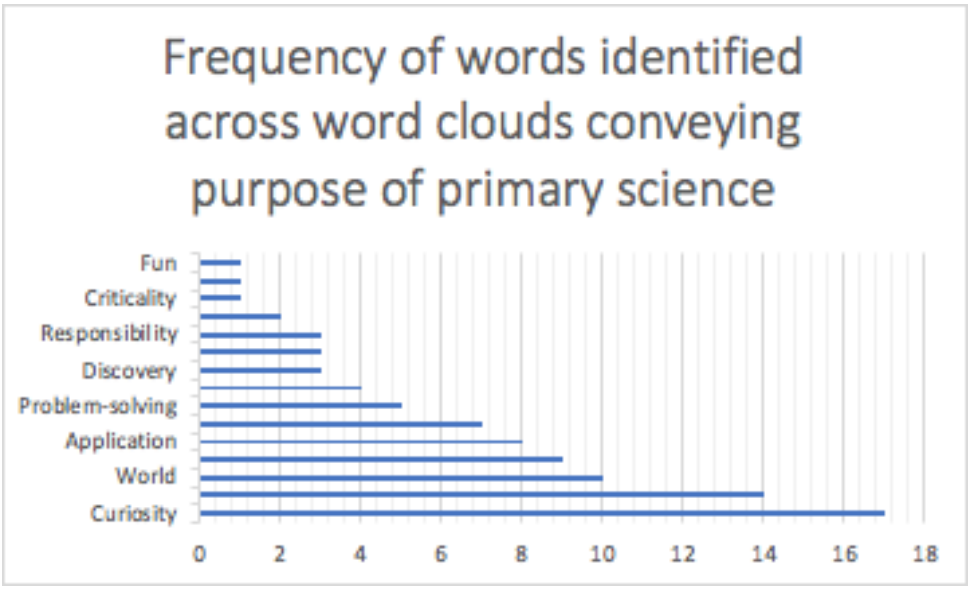
were recorded into word clouds (Figure 6.2, p.88), within which the biggest words represent a higher frequency of times the word or phrase has been mentioned.

Figure 6.2. Group word clouds highlighting beliefs about the purpose of primary science education.



(Clockwise from left: School a, 12 delegates including a head teacher, leader of primary science, teachers and students; school b: 15 delegates, leader of science, no SLT; ASE conference: advisors, leaders of science, teachers; Pre-service teacher workshop: 12 pre-service teachers).

Figure 6.3 Frequency of words identified across word clouds conveying the purpose of primary science



The words that feature most often across the word clouds included: nature, world, perspective, curiosity, sustainable, respect, responsibility, innovation and society, all of which reflect the attitudes and values of a global learner, as identified in both in the Oxfam's Global Citizenship framework (2015) and in the OECD Global competences, OECD (2018a). Findings, therefore, suggest that when stakeholders think beyond their own curriculum aims, there is a common belief that attitudes, and values related to global learning are central to the purpose of primary science education.

6.2.6 Beliefs about different aspects of global learning

Through using the attitudinal survey, groups were compared in relation to different aspects of global learning, as can be seen in Table 6.5, below.

Table 6.5 Comparing attitudes to global learning of different groups

	Advisors	SLT	HOD	Teachers	Pre-service
Whilst creative thinking in science is important there are things which take a higher priority	3	0	0	6	0
Global learning is too complex to engage with	1	0	0	0	0
Global learning in science is possibly one way to promote critical thinking	25	14	14	19	25
Global learning adds to pupil learning in science	18	19	19	24	26

When focusing on the development of critical thinking, it was evident that there were disparities between the frequency of those who agreed with the item in the attitudinal survey and those who identified it as an important aspect of the purpose of primary science education. This may subsequently impact on their engagement of the global learning approach, if they do not consider the approach will add value to their primary science.

Table 6.6: Comparing agreement with the item of critical thinking both in the attitudinal survey and the interviews

	Advisors	SLT	HOD	Teachers	Pre-service
Global learning in science is possibly one way to promote critical thinking	25	14	14	19	25
Frequency of respondents who identified critical thinking as a purpose of primary science education	1	1	3	1	0

Whilst 25 out of 30 advisors agreed that global learning was one possible way to promote critical thinking (Table 6.5 and 6.6 above), only one advisor highlighted critical thinking as an important aspect of the

purpose of primary science education. When exploring this further in the interviews, it was highlighted that advisors often prioritised security of knowledge and understanding:

> *'I think teachers need to understand the importance of cognitive load, so that they really appreciate the importance of developing basic knowledge before enabling children to relate it to their own lives, to problems, the real world or to think critically about ideas'.*
> **Advisor 4 – Semi-structured interview. Appendix XXXIII, p. 219**

Contrastingly, whilst three out of five interviewed heads of science identified critical thinking as an important skill developed through primary science education, less than half (14 out of 30) agreed that global learning in science was a way of promoting critical thinking. As critical thinking is an integral aspect of the global learning approach to primary science, the lower number agreeing in the survey could indicate the need to develop a better understanding of the approach, whilst enabling respondents to consider its value and importance within primary science education.

Prior studies highlight the relationship between critical thinking and increased attainment and further engagement in science learning (Winterbottom and Winter, 2017) and other studies recognise the link between critical thinking and increased ability to tackle complex issues (OECD, 2019). Considering the value of critical thinking in primary science, and how this can be developed through a global learning approach could therefore be suggested as an important area of subject-specific professional development.

Further to this, all case study schools readily incorporated critical thinking into their global learning science planning using resources such as Explorify (see documentation of planning, Figure 6.4). Case study school C identified critical thinking as a real strength to the global learning in primary science approach.

> *'One teacher highlighted that this was the most useful aspect of the approach, getting children to see things from different perspectives. She began to discuss further opportunities for using global learning critical thinking activities as formative and summative assessment opportunities'*
> (Appendix XXVI p. 209, reflective interview with Head of Science in case study school C).

As the reflective interviews go on to explain, making explicit the links between the global learning approach, the skill of critical thinking and the consolidation of core science knowledge not only requires further exploration, but has the potential to engage more leadership and advisors of primary science.

6.2.6.1 Creative thinking

As a core element of the global learning approach, creative thinking was an important aspect of the global learning approach, enabling children to apply their learning to new contexts. Considering stakeholder attitudes toward the construct of creative thinking provided insight into the integration of this strategy.

	Advisors	SLT	HOD	Teachers	Pre-service
Whilst creative thinking in science is important there are things which take a higher priority	3	0	0	6	0
Frequency of respondents who identified creative thinking as a purpose of primary science education	0	0	0	0	0

Table 6.7: Comparing agreement with the item of creative thinking both in the attitudinal survey and the interviews

The item related to creativity, 'whilst creative thinking is important there are things in science which take a higher priority', with only 13 out of 180 agreeing with this statement, demonstrated that the remainder of respondents disagreed. Furthermore, when comparing this data with respondent beliefs of the purpose of primary science education, creativity was not identified at all.

As described by Cremin and Barnes (2015), creativity is the process represented by the mechanics of learning, thinking and communicating through posing questions, play, immersion, innovation, risk-taking and being imaginative. The thematic analysis of the semi-structured interviews highlighted that all five teachers identified time as an inhibiting factor to engaging with a global learning approach. This mirrors the recent 'State of the Nation' reports (Wellcome, 2017a) which, as discussed in the literature review, highlights that the average school only has one hour and 23 minutes of science per week per class. It is, therefore, understandable that even if teachers do believe creative thinking is an important aspect of the purpose of primary science, they may prioritise the attainment descriptors of the teacher assessment framework (DfE, 2018).

This idea is confirmed by Liu and Lin (2014) who agree that creativity in science is often misunderstood by primary teachers and thus not central to science teaching. Liu and Lin's research identified the central notion of scientific creativity as a process of organising and connecting ideas, enabling children to identify gaps in knowledge and problems that need to be investigated. This idea of creativity in primary science is built upon by McGregor and Wilson (2017) who discuss the importance of 'teaching for creativity' in which children are facilitated to build on science ideas by generating original ideas and using science as a platform for inventiveness. Resultantly, having a better understanding of scientific creativity (within the global learning approach), could enhance inquiry-based learning, as well as support children to remember, arrange and combine facts and other information. Subsequently, these findings suggest three things: firstly, there may be a need to support teachers in understanding what

creativity looks like within primary science; secondly, teachers may need to be supported to understand how creativity in primary science does not mean adding something additional to an already packed curriculum, and thirdly, science education requires more time to do justice to creativity.

Furthermore, creativity, as identified by Schleicher (2018) is one of the most important skills of the future, especially as global problems become more complex. Creative thinking, as defined by the OECD (2016), is about extrapolating from what we know and applying that knowledge creatively in novel situations, and about thinking across the boundaries of subject-matter disciplines, including science. Findings from all three case-study schools (which will be discussed further in Chapter seven) incorporated creative thinking into their planning:

Table 6.8 Examples of creative thinking in primary science education

	Examples of creative thinking	**Evidence**
School A	Each class focused on different SDGs and children were given the opportunity to share how they could use their science knowledge to make changes to help solve global issues, e.g. reducing food waste. Children were given the opportunity to design posters to share their ideas about how to investigate and solve problems, using the science knowledge they had learned.	Figure 6.4
School B	The school's science week included a theme for each year group. This included an 'inquiry' and 'innovation' stage during which the children were given the opportunity to investigate and apply their findings by designing something that solved a problem.	Figure 6.5
School C	The planning from this school involved the integration of questioning that facilitates the application and connection of new knowledge, e.g. 'why would you like to live in space?' but also concludes topics by asking children to solve problems, e.g. 'what would you do to protect the rainforest?'	Figure 6.6

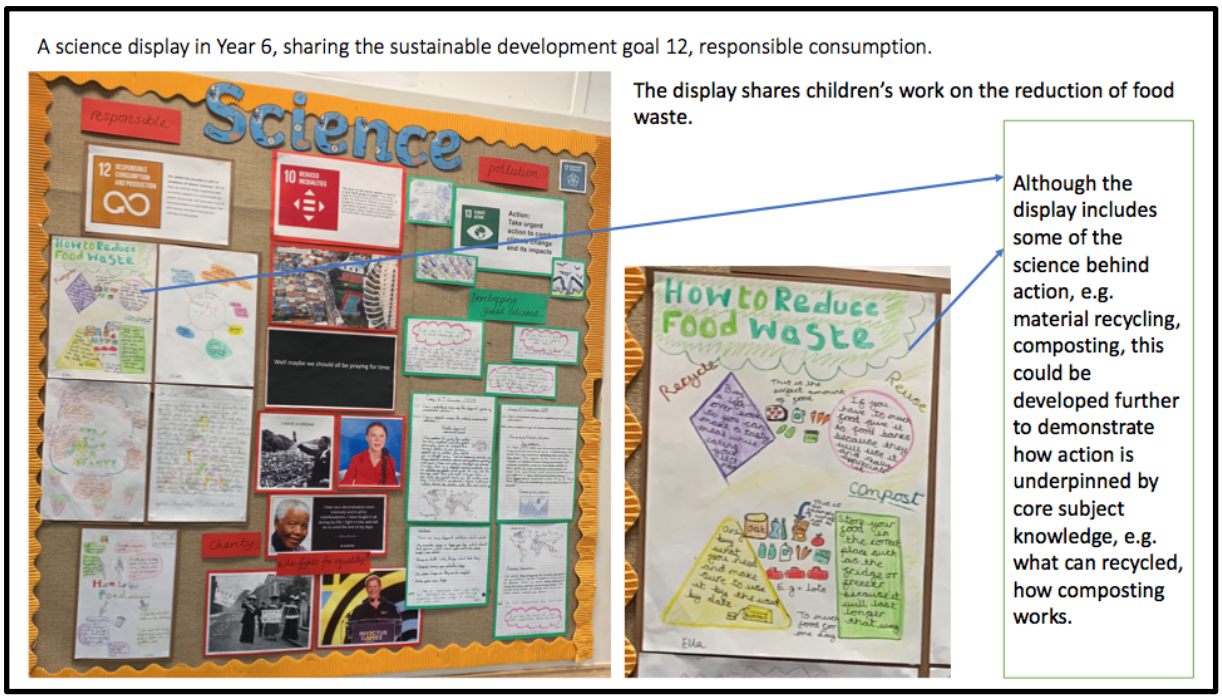


Figure 6.4 Creative thinking in science learning in school A.

All three head of science teachers from the case study schools conveyed that this application of science knowledge gave them the opportunity to find out and assess what the children had learned (as identified in my reflective diary, appendix XXVI, p. 209). This finding confirms how creativity can not only support engagement and improved attainment, as suggested by McGregor (2017), but provides an opportunity to demonstrate how creativity in science learning mirrors the creative nature of science in the real-world. The evidence from the case study schools, however, shows that some aspects of scientific creativity may still be missing. For example, none of the three case study schools identified the use of creative reflection, such as supporting the children to evaluate their thinking or consider improvements for something. Consistent with McGregor and Wilson (2017), the elements of creativity related to expressing and developing thinking in science need to be developed.

A recent systematic review of literature related to creativity and science education (Aguilar and Turmo, 2019) identified that enhancing creativity in science education engaged all students in active and collective knowledge creation as well as equipping them with necessary skills, that is being resourceful and dynamic, to become global citizens. This is endorsed by 4C's competencies (Phillipson and Wegerif, 2020) of creativity, collaboration, criticality and caring, supporting engagement with other points of view. This has further been reinforced by Cheng (2010) who confirms that reforms around the world have introduced creativity as a key target in science education. Recent reports have also highlighted the importance of ownership and creativity in science aiding the improvement of 'science capital' without diluting content (Godec, King and Archer, 2017). And perhaps most pointed, but arguably implicit, the current National Curriculum in England (DfE, 2013) highlights the importance of ensuring children develop a variety of approaches to scientific enquiry as this mirrors the creative nature of contemporary science solving global issues. As the surveys and interviews echo, respondents see

creativity as being important in science, but until it becomes central to policy and planning, its importance will be lost in the struggle to cover the content of the programmes of study.

Finally, in Table 6.9, the proportion of each stakeholder group agreeing to the statement 'Global learning adds to pupil learning in science' was compared to that of the entire survey population using a chi-squared test. The advisor, SLT and HOD stakeholder groups had a significantly lower number of respondents agreeing with the item (p value = 0.03), (arguably the more influential stakeholders in terms of supporting changes in primary science pedagogical approaches)

Table 6.9 A table comparing the number of individuals in each group agreeing with the statement: 'Global learning adds to pupil learning in science'

	Advisor	SLT	HOD	Teacher	Pre-service	Total who agreed
Observed	18	19	19	24	26	106 out of 120
Expected	26.4	26.4	26.4	26.4	26.4	88%

When exploring this further during interviews, advisors, head teachers and heads of science all demonstrate concern regarding teachers' science subject knowledge and knowledge surrounding global issues which may impact on their ability to use the approach effectively. This is demonstrated by one of the advisors who stated:

> *My heart says that this is a great idea, but I worry that there is not enough time to ensure that the teachers have secure knowledge and skills in science to underpin a global approach with links to sustainable development goals (Advisor 6, Semi-structured interview, appendix XXXI, p. 216).*

This finding suggests that the reason for not believing that global learning adds to pupil learning in science is not about the approach, but about who and how it is taught, as well as the time required to plan and deliver it effectively. I would agree that in my own role as a teacher educator, colleagues are cautious when integrating new pedagogical approaches into trainee programmes, choosing to focus on the central aims of the curriculum (reflective diary, appendix XI, p. 185).

Positively, all groups in general did not indicate that global learning in science is too complex to engage with. Whilst this contradicts the findings above, this data suggests that respondents are not deterred by the potential complexity of the approach. However, as will be discussed in the next chapter which focuses on professional development, considering how children and teachers engage with a global learning approach and related global issues needs to be explored further. Chapter 7 will explore the research data in relation to professional development, and the opportunity to support teachers in the delivery of a global learning in primary science approach.

6.2.7 Teachers' attitude changes concerning global learning in primary science

Literature has identified that beliefs and attitudes are difficult to change (Pajares, 1992) and changes are often small and incremental (Terhart, 2013). This sentiment was evident across the case study schools, but findings showed that attitudinal change occurred. All three case study schools conducted the global learning in primary science workshops, along with follow-up support with planning and resources. Interviews with respondents from each school were conducted after implementation, along with the collection of evidence in the form of photos of displays, children's work and medium-term plans. Table 6.10 below shares a summary of how the approach was integrated into each school.

Table 6.10 A table showing how the global learning in primary science project impacted on the approach to science in each school

Case Study School	Head of science attitudinal survey score	Examples of implementation	Continued / embedded evidence of change	Challenges to change
A	6.6 (Respondent 20)	● Global learning assembly embedding goals. ● Global goals assigned to classes to develop a familiarity of them before applying it to learning. ● Use of Practical Action (an online resource) in schemes of work which relate science learning to global issues and problem-solving activities. ● Global learning and science display in each classroom ● Planning format changed to include the sustainable goals, global citizenship 'heroes' and action.	Planning changed to demonstrated how sustainable development goals underpinned knowledge and working scientifically development using a new knowledge and skill organiser (Appendix XXVIII, p.221)	● Time management – although teachers have enjoyed researching; ● Ensuring that they understand the links between science and the SDGs; ● Teachers have had to do a lot of personal research and detailed planning.
B	5.8 (Respondent 21)	● Global STEM week to implement knowledge and understanding to an innovative project (see appendix 29, p.230) ● Integration of global learning pedagogical strategies into planning, including critical thinking, philosophy for learning; ● Medium term plans now include a global learning section, focusing on the core values linked to the programme of study.	Changes to planning	● Some teachers resistant to change; ● SLT did not attend GLPS workshop; ● Global learning appeared to be an additional column on planning (as per evidence) rather than integral to the planning
C	6.2 (Respondent 4)	● Integrated into schemes of work ● Professional development relayed to other members of science teaching team ● Collaboration with Senior leadership to develop related ethos ● Change of school's science policy	Engagement and delivery of CPD to whole science team	● Not consistent across school

School A, in which the head teacher and head of science were both strong advocates of global learning and sustainable development education from the outset were eager to implement the framework and did so successfully over a sustained period (Table 6.8, above). As detailed in the school summary in table 6.2 this school was simultaneously conducting a Primary Science Quality Mark, therefore was able to incorporate global learning into its science vision (Appendix XXVIII, p. 220). Subsequently, through systematic action planning, the sustainable development goals were incorporated into science planning across the school. Unfortunately, as this study highlighted, embracing an approach for an extended period is needed to observe changes in student outcomes (Guskey, 2016). However, the findings reveal that quality of learning was rich and demonstrated progression of knowledge, skills, as well as attitudes (evidenced through children's work, collaborative displays and talking to children about their learning, appendix XXVII, p.211). Consideration of how the pedagogical approach is underpinned by a school's science vision may be central to its incorporation.

School B not only had the least positive head of science (with a score of 5.8) towards global learning in primary science, but during the initial whole school workshops, both headteacher and deputy headteacher were not present. Whilst there are many explanations for senior leadership team being absent from in-service training, a reflective discussion with the head of science articulated that the Senior Leadership Team priorities were areas in their school development plan and science did not feature (Appendix XXVI, p.208).

Medium term plans did show an additional column in their science planning, identifying global learning values related to the science learning, and a standalone science week focus embraced global learning through a thematic approach (see appendix XXIX, p. 212). The response from both teachers and children after the science week with a global learning focus, reiterated how the approach enabled learners (and their teachers) to see the relevance of science knowledge and skills to global issues. As one teacher responded, 'it gave me a real opportunity to assess children's understanding in a more creative way' (post-CPD interview, Appendix XXVI, p. 208) and another teacher agreed, 'I ended up working backwards to see what knowledge the children would need to solve the global issue and realised these met a lot of the curriculum objectives' (post-CPD interview, Appendix XXVI, p. 208). During the post-CPD semi-structured interviews with the head of science, asking about what they would do next, they responded by suggesting they would repeat the successful science week next year. Whilst this finding suggests that the school and head of teacher still saw the approach as a bolt-on, rather than central to science teaching and learning, exploring the impact of these initiatives could lead to further change (which may not be observed during this study).

In School C, whilst the head of science already had a positive attitude toward global learning in primary science, identified in their survey score of 6.2, the head of science highlighted that other teachers in their school did not engage with changes in their planning and focused on the original content (semi-structured interview, appendix XXVI, p.208). Whilst in the first term, they saw positive impacts on pupil

outcomes and engagement, they found it difficult to impose new approaches on colleagues who had been teaching for long periods (See appendix XXVI reflection, p.208). They articulated that having consistent evidence of the project's impact would have given them more authority to encourage a new approach amongst her colleagues, as well as convince their SLT of the positive impact of the new approach. However, further visits to the school demonstrated that other colleagues had begun to take on board the new ideas within their planning and it was becoming integral to the school's science approach (reflective interview 2 school C, appendix XXVI, p.209). The head of science identified that once time was given to plan exciting themes, teachers began to adopt ideas.

> '*The head of science discussed how SLT had given planning time and this was the changing point, adding enthusiasm and giving her team thinking time to be creative about implementing global dimensions,' (Reflective diary entry after discussion with Head of science from school C).*

All three school case studies shared evidence of critical thinking activities and global issue problem-solving tasks as part of their implementation of the approach. However, all reflective discussions highlighted that whilst enjoyable and interesting, planning with a global learning lens was time consuming to ensure that resources were appropriate and supported the children's questions. For example, a teacher from school B highlighted that they had no idea where to start when looking at materials that would be useful in the future.

What was evident from all three case studies was that the initial interviews of the heads of science from these schools highlighted their belief of global learning in primary science approach aiding engagement and motivation of learners (all highlighting the benefits of engagement, motivation and relevance in their interviews prior to the CPD). They all, however, underestimated the amount and type of planning required to teach with a global learning perspective. For their colleagues who had not undertaken the project from the start, identified planning with a global learning approach as time consuming rather than as an opportunity for effective science learning. This highlights the importance of teachers' own beliefs related to global learning as being fundamental for any sustainable integration of this pedagogical approach.

All teachers who engaged in the global learning in primary science approach demonstrated a shift in their beliefs concerning the pedagogical approach (as evidenced by their reflective interviews). For example, school C recognised global learning as an opportunity for students to apply new knowledge both as a form of assessment and a consolidation / retention of knowledge. Schools B and C recognised that global learning in primary science offered greater opportunities for critical thinking and the use of knowledge for problem-solving and application of knowledge to wider community projects. This demonstrates the importance of a cyclical approach to professional development in order to change beliefs, attitudes and perspectives towards pedagogical approaches. How to engage and challenge approaches from the outset is still an area for further exploration.

6.3 Chapter Summary

Through an analysis of data from different stakeholders, along with three case study schools, this chapter explored the relationships between beliefs, engagement and practice related to a global learning approach to primary science education. Firstly, teachers' beliefs regarding the purpose of primary science impacted on further engagement with the approach.

Whilst these beliefs do not directly or naturally convert into a global learning science teaching approach, there is an opportunity to help respondents consider how their own beliefs align with a global learning approach, which as highlighted, is fundamental to any change in pedagogical approach. However, like other countries, articulating these attitudes within policy may provide a framework to formalise these purposes and ensure a consistent approach to a primary science fit for a global society.

This analysis also highlights the importance of teachers and schools developing their own vision and principles of primary science which incorporates a global learning approach. This allows for a more consistent approach to planning and teaching, as well as greater collaboration amongst teachers, as evident in school A. Until substantial impact of the approach on children's learning has been obtained, those who influence and advocate changes in pedagogy may be resistant to use valuable professional development time to engage with and share the approach. Making explicit the centrality of global learning skills such as creativity and criticality within science learning to prepare future global citizens will therefore require a multi-pronged approach: challenging beliefs of the purpose of science, explicit targets in science curriculum and developing a shared vision. Considering the role of professional learning in the integration of a global learning approach will be discussed in the next chapter.

CHAPTER 7 FINDINGS OF THE PROFESSIONAL DEVELOPMENT APPROACH TO GLOBAL LEARNING IN PRIMARY SCIENCE

7.1 Introduction

Chapter seven considers the findings related to professional development and teacher education in primary science. It will inform an understanding of how stakeholders engage with professional learning, specifically in relation to primary science education. Chapter 2 conceptualised professional development as a process of supporting the development of practice and Chapter 4 provided a rationale for the global learning in primary science professional development and subsequent approach. As identified by Schleicher (2019), measuring changing practice has proven difficult. Demonstrating a positive attitude towards a new approach or highlighting potential benefits does not directly translate into changes in pedagogical practice.

Within the scope of this study, however, findings in this chapter will consider the effectiveness of the strategies used to support professional practice. Specifically, through the data collected from the semi-structured interviews, aspects of the attitudinal survey, reflective diary entries and collections of teachers' planning and examples of learning, the impact of the professional development workshops and accompanying support are used to inform opportunities to develop science with a global learning perspective.

7.2 Professional development: the approach

Chapter 4 outlined the global learning in primary science approach, with a rationale for the strategies employed. In relation to the overarching research question, the review of literature suggested that success of professional development is influenced by respondent ability to recognise any potential benefits of an approach (aligned with their personal and professional beliefs) as well as being able to consider how the approach can be implemented successfully. In line with the research of Hajisoterio et al., (2019), who demonstrated that at the centre of professional learning are the teachers, the findings will outline the perceptions and preconceptions of the teachers (and other groups) which influence the development and organisation ITE and CPD, considering both theoretical and practical implications.

7.2.1 Strategies used to develop a global learning approach to primary science education

Three themes emerged concerning general strategies influencing teachers' practice. These included: looking beyond the National Curriculum to establish a shared vision, effective platforms to share practice, resources and ideas consistent with a global learning approach and providing a framework for planning. Each theme is discussed below.

7.2.1.1 Looking beyond the National Curriculum in England to establish a shared vision

The curriculum framework in England is understandably central to the engagement and implementation of any new pedagogical approach, and perhaps necessary for curriculum coherence, as Myatt (2018) describes as when curriculum content, pedagogy, assessment and incentives all align. Appendix XXXII, (The semi-structured interview responses related to global learning in primary science professional learning) on page 215 and appendix XXXIII on page 218 (Semi-structured interview responses to question: 'How do you think teachers and trainee teachers should be supported to relate their science curriculum to the real world and global issues?) highlight that all respondent groups identify the importance of linking the global learning in primary science approach to a curriculum framework. A common theme from the interview responses was the importance of developing teacher knowledge and confidence in relation to global issues, the global learning approach teaching strategies and SDGs. A summary of these responses in Table 7.1, below, demonstrate the importance of developing pedagogical content knowledge (related to global learning) as well as subject knowledge in relation to the approach.

Table 7.1 Respondent recognition of the importance of support to make links between the National Curriculum and Global Learning in Primary Science Approach

Comment	**Respondent**
Clear links by unit of study/ NC objective would be useful	SLT3
Building confidence in the teachers for them to feel like they can adapt the curriculum to today's world by supplying them ideas of how to link (again through resources and training) and apply the curriculum to meaningful contexts.	HOD 3
Global issues / SDGs need to be integral to the curriculum – thus giving consultants and ITE providers the impetus to equip teachers with the skills to integrate it	A2
More awareness of SDGs as a teacher trainer. As I focus on the curriculum framework, I believe that unless they are part of the policy, I suspect any integration will be sporadic and not consistent across schools	A4
Without being part of the curriculum policy, it is difficult to ensure this is done with consistency.	A4
More modelling and awareness of global learning, strategies and how things can be incorporated into an already squeezed curriculum	T3
I also think that we need free and up-to-date resources that relate the curriculum to current issues	T2
Our programmes of study (NC) and schemes of work need modern, relatable themes, for example. recyclable fashion, exploring food packaging	S3

In both semi-structured interviews and reflective discussions with the three case study schools, being able to make valid links between the Sustainable Development Goals and the science programmes of study was an important factor for successful implementation. For example, when teachers could see clear links to the National Curriculum (DfE, 2013), they reported that they were more likely to incorporate it into planning; a finding also reported by Penuel and Fishman (2012):

> *'We began by identifying which sustainable development goals linked to the programmes of study being taught this term, which was easier than we thought. 'we were actually using many already without even realising it! Year 6 were looking at the impact of diet and exercise on their bodies, which was clearly related to Sustainable Development Goal 3, good health and well-being'.*
> (Appendix XXVI, p.209 Case study school A head of science, reflective interview)

And for some teachers, it was useful to see what they were already doing in their programmes of study which related to the global learning approach:

> *'In Year 4, we were already looking at rainforests as a theme for the living things and their habitats programme of study, so looking at sustainable development goal 15 and considering our impact on the environment was something we just needed to develop further'.*
> (Appendix XXVI, p.209 Case study school C head of science, reflective interview).

As identified in Table 7.2 on the page below, the three case study schools were able to identify explicit links between their programmes of study and the Sustainable Development Goals. It was also clear that depending on the context used to deliver the programmes of study, links between science and sustainable development were not always the same. For example, Schools B and C both incorporated global learning into their Year 2 using everyday materials topic: School A focused on the responsible consumption of materials, whereas school B focused on the use of materials for industry, innovation and infrastructure. This highlights two considerations: firstly, the importance of teacher and school autonomy in making links relevant to their learners and, second, the need to ensure that teachers have a thorough understanding of all goals, to integrate the most appropriate goal to the content of their teaching.

School A	**School B**	**School C**
Year 1 Everyday materials – SDG 12 (Responsible consumption)	**Year 1 Everyday materials** – SDG 9 (Industry, Innovation and infrastructure), SDG 12 (responsible consumption), SDG 14 (life below water)	No links identified
Year 2 Uses of everyday materials – SDG 12 (Responsible consumption)	**Year 2 Uses of everyday materials** – SDG 9 (Industry, innovation and infrastructure)	No links identified

Year 3 Animals including humans – SDG 2 (zero hunger)	**Year 3 Plants** – SDG 2 (Zero hunger)	**Year 3 Plant, animals including humans** – SDG 15 (life on land), SDG 2 (zero hunger)
Year 4 States of matter – SDG 13 (climate change)	**Year 4 States of matter** – SDG 6 (Clean water and sanitation)	**Year 4 Living things and their habitats** – SDG 2 (zero hunger)
Year 5 Life cycles – SDG 2 (zero hunger), SDG 15 (life on land)	**Year 5 Forces** – SDG 7 (Affordable and clean energy), SDG 9 (Industry, innovation and infrastructure), SDG 13 (climate change).	**Year 5 Earth and Space** – SDG 9 (Industry, Innovation and infrastructure)
Year 6 Properties and changes of materials – SDG 13 (climate change), SDG 12 (responsible consumption)	**Year 6 – Living things and their habitats** – SDG 3 (good health and wellbeing), SDG 6 (clean water and sanitation)	**Year 6 – Animals including humans** – SDG 3 (Good health and wellbeing)

Table 7.2: Links between primary science programmes of study in England (DfE, 2014) and Sustainable development goals (UN, 2015).

From the attitudinal survey, individual items were analysed when considering stakeholder motivation to engage in the professional development. These items in Table 7.3, below, comparing attitudes of different stakeholder groups towards the integration of a global learning approach. Within table 7.3, those agreeing with each statement is indicated as a number and percentage. For example, 70% or more teachers and pre-service teachers agreed that 'Global learning in science is essential for the development of teachers and those they teach', only 13% or less considered global learning as a low priority, and SLT aside, all stakeholder groups considered global learning to be part of their role as a teacher.

Table 7.3 Survey items related to teaching Global learning in primary science

	Advisors	**SLT**	**HOD**	**Teachers**	**Pre-service**
Global learning in science is essential for the development of teachers and those they teach	17 (57%)	6 (20%)	18 (60%)	21(70%)	25 (83%)
Global learning is a low-priority issue on the scale of what is important in primary science	4 (13%)	6 (20%)	3 (10%)	0 (0%)	4 (13%)
Incorporating global learning is beyond the role/scope of being a teacher	0 (0%)	6 (20%)	0 (0%)	0 (0%)	0 (0%)
I hate the whole idea of teaching about global learning in science lessons	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
I am very passionate about global education	7 (23%)	2 (7%)	8 (27%)	5 (17%)	16 (53%)

It may be acknowledged that these stakeholder groups may have had a limited understanding of the global learning approach and therefore may be overly positive, However, further explorations within the interviews of these groups identified that they saw the potential for the global learning approach as

providing a purpose for the knowledge and skills articulated in the programmes of study. As shared in Table 7.4 below, a range of comments highlight possible reasons for these positive attitudes towards incorporating a global learning approach. These comments including words such as realistic, meaningful and motivating, demonstrate the potential for the global learning approach to provide a real purpose and context for learning scientific knowledge and skills in the curriculum.

Table 7.4 Semi-structured interview responses related to the Global Learning approach

Comment	Respondent
It makes learning realistic, practical and memorable	SLT 1
It provides a purpose for what is being learned beyond the teacher assessment framework	HOD2
It will be useful to develop the application of learning	T2
I think it will be motivating for me and the children	A1
By making science more meaningful to the children they are more likely to take the knowledge away with them and use it	S3 T1
It brings the curriculum to life.	HOD 1
An important dimension to making the learning interesting in science	HOD3

Conversely, this was not the same for all advisors, SLT and Heads of Department (arguably having a more realistic outlook). Semi-structured interview data highlighted that some individuals from these stakeholder groups identified the priority of subject knowledge identified in the curriculum.

For example, Advisor 4 (Appendix XXXII, page 216) states:

'I don't think it [Global Learning] should be a priority due to the lack of time schools / teachers have. Teachers need to appreciate the importance of developing basic knowledge before enabling children to relate it to the real world'.

Headteacher 4 (appendix XXXII, page 216) also agrees:

'Teachers don't have time to go beyond the objectives in the programmes of study'.

This is an important finding, demonstrating perspectives vary according to roles and responsibilities when considering engagement in global learning professional development, highlighting the theme of time impacting on the need to prioritise curriculum coverage from a leadership perspective. However, beyond the curriculum programmes of study objectives, an important finding was the significance of 'meaningful' learning and 'contexts' for scientific enquiry identified in the attitudinal survey, interviews and case study schools. As one head of science stated when asked what can be done to support the

teachers to relate the science curriculum to the real world and global issues, they stated that professional development needs to:

> *'Build confidence in the teachers for them to feel like they can adapt the curriculum to today's world [can be done] by supplying them ideas of how to link [the curriculum to global issues] (again through resources and training) and apply the curriculum to meaningful contexts.'*
> (Appendix XXXI, page 216. Head of Department 3).

Further to this, whilst teachers and pre-service teachers were able to identify which goals related to the science programmes of study, they needed support to develop themes and 'innovation' activities for each year group:

> *'We wanted to use the global learning approach to empower the children, but it took a long time to make sure we had meaningful and authentic themes to underpin their knowledge and skill development. Having an advisor and planning time to do this really helped. We were really pleased with [our] planning.'*

(Appendix XXVI, page 209: Reflective interview excerpt from the head of science from case study school B).

As this excerpt also recognised, developing themes that 'empower' children and teachers, links to the concept of using global learning in primary science to support teachers and children as agents of change through enabling them to envisage future possibilities, as identified by Priestley's (2015) approach to agency. Considering and supporting teachers and schools with relevant themes to support the global learning in primary science approach could be fundamental for its success.

This was also reiterated by the findings of the interviews which revealed an acknowledgement from all groups that additional support is needed to enable them to both make links between primary science and global learning, as well as provide global contexts and activities to which apply science knowledge and skills, as illustrated by Table 7.5.

Table 7.5 Summary of evidence from semi-structured interviews highlighting the importance of guidance and links between global issues and the science curriculum

Comment	***Respondent***
A framework on which to hang the curriculum on, and provide a context to bring the curriculum to life;	*Advisor 5*
Recommendations for good videos and interactive tools so that you feel that you are working towards something beyond assessment;	*Teacher 4*

Support from specialist science teachers would ensure a rich science curriculum with real life application	*Teacher 5*
Encourage teachers to be more confident in teaching science and creating fun and meaningful lessons and investigations to support learning.	*Advisor 3*
More modelling of effective lessons which bring pedagogical strategies and creative ideas together through themes.	*Pre-service teacher 4*

When reflecting on the impact of the approach with the case study schools, findings revealed a positive impact on their science. During a reflective discussion with a focus group of teachers in school A, one teacher stated:

> *'We felt that this was the missing link, and motivated teachers and children.'*
> (Appendix XXVI, page 209, Case study school A, a reflective discussion)

The school and the children's work (see the examples shown in Figure 7.1, p.109) highlighted that being able to enable the children to use their science learning to consider ideas related to global issues was both empowering and consolidated core learning. The sample includes the question, prompted by the teacher, 'what can be learned?' allowing the children to reflect on their relationship and responsibilities towards climate change and rising sea levels. Again, this aligns with Bianchi et al (2021) who's recent report highlights the need to ensure enquiry in primary science has real purpose.

What must be acknowledged, as the examples below show (and what is evident from my own reflective diary), is that the underpinning science learning (both concepts and the nature of science) must not be lost. For example, when identifying an action of 'making compost', it is unclear whether the children have the systemic thinking to be able to explain how an understanding of how compost is made can support sustainable consumption. This, therefore, identifies the importance of professional development equipping practitioners to be able to ensure that children can be encouraged as agents of change through drawing on their core science learning. This is further demonstrated in Figure 7.2 on page 106; whilst celebrating a link between science and the SDGs, there was little evidence of scientific reasoning. As one child's work stated, 'we should preserve food', but did not explain why this would help food last for longer. It was clear, however, that the school was proud of their science and felt motivated by the approach (reflective diary XXVI on page 209 stated how one teacher was so excited to show me their children's books). This is verified by School C, which after the first round of planning, decided to continue to use global learning in their science schemes of work.

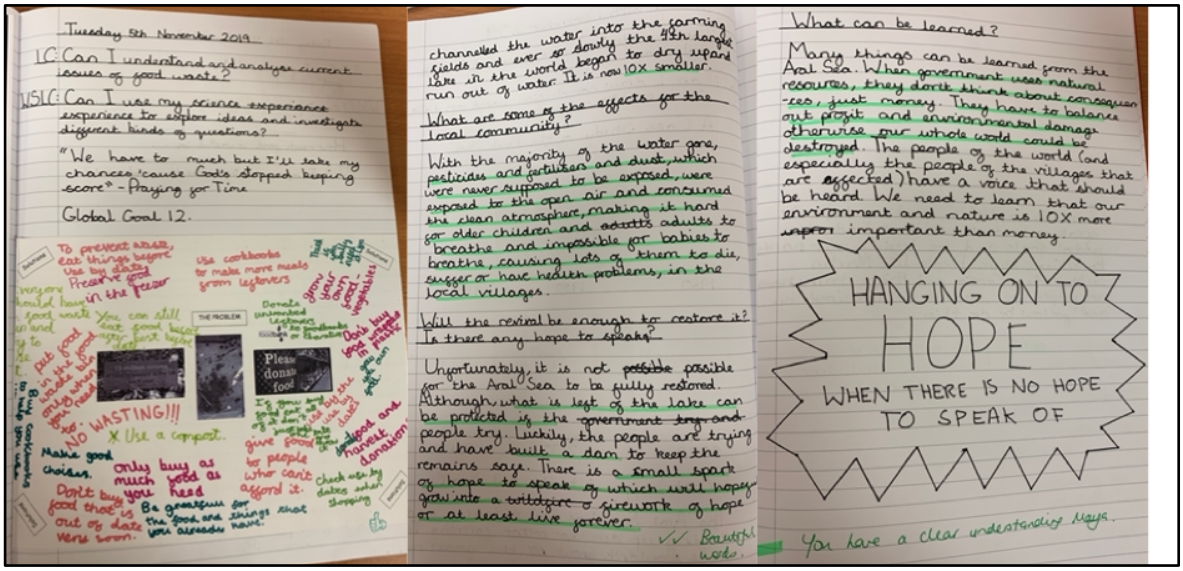


Figure 7.1 Samples of work from school A

Figure 7.2. A display of work from school A

The concern that disciplinary knowledge would be lost in a global learning approach is important to acknowledge for two reasons. Firstly, because the approach in this study is underpinned by the belief that global citizens should be informed by a secure foundation of science knowledge and skills. Secondly, because as discussed above, stakeholders understandably prioritise the delivery of the curriculum content. This appeared to be the case in some of the displays, as Figure 7.2 shows, along with further examples in the Appendix XXVIII, page 212. However, a closer look in the planning and

children's independent work demonstrated that key science knowledge and working-scientifically skills from the National Curriculum (DfE, 2013) were evident throughout (See appendix XXVIII). Figure 7.3 below, for example, demonstrates that working scientifically skills of predicting, investigation planning, observation and changes of states underpinned a lesson about climate change and rising sea-levels. As will be discussed further in Chapter 8, considering how to marry science-specific knowledge and skill rigour with the capabilities and aims of a global learning approach will be important in its success.

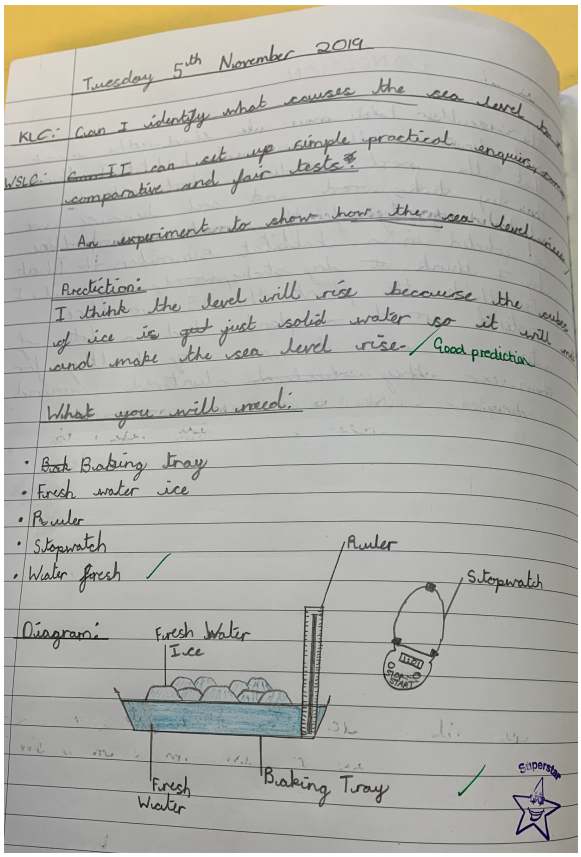


Figure 7.3 An example of science learning through a global learning approach in school A.

7.2.1.2 Effective resources and activities

All case study schools made greater use of the more accessible strategies and related resources (see Table 7.6, p.112). For example, all schools used Explorify to support the strategy of critical thinking as these resources are readily available online for all science programmes of study. However, when strategies required teachers and schools to adapt strategies and construct their own resources specific to an area of science, such as P4C and Open Spaces for Dialogue and Enquiry, they were not used. This may be a result of time constraints but may also be due to the changing nature of how teachers seek online resources and social media links which can be immediately implemented in the classroom (Ortlieb, 2018) and have been tried and tested. This is also demonstrated in table 7.6 which highlight a higher frequency of respondents using immediately implementable online resources. As the brainstorming session with school C (Appendix XXXIII, page 222) demonstrated, along with the reflective interview with their head of science (Appendix XXVI, page 209), it took time and

collaboration to determine themes that supported the development of core science knowledge and skills, whilst being relevant and motivating to the children. Strategies and resources were referred to in two ways: those trialled in the global learning in primary science workshops, and those available on established online platforms, for example, The Wellcome Trust Explorify website and Practical Action. What was evident from my own reflective diary was that I noticed that practitioners being able to trial the activities and strategies in the workshops with other colleagues enabled them to explore their own understanding as well as consider where and how they might be implemented in practice (XII p.190).

	School A	School B	School C
Critical thinking	Explorify (Big questions, odd one out) Group discussion and listening to each other's' ideas	Debates, collaborative discussion	Explorify (Big questions, odd one out) Values on a line
Philosophy for children (P4C) / Community of scientific enquiry	x	x	x
Open Spaces for dialogue and enquiry (OSDE)	x	x	x
Creative Thinking	Practical Action resources Woodland Trust activities – e.g. to support diversity in local habitats	Practical Action activities and resources NASA resources	Train like an astronaut resources (National STEM centre)
Global Issues	Reachout reporter (Online global science news) Blue planet	Blue planet	Reachout reporter (Online global science news) Rainforest foundation UK

Table 7.6 A record of Global Learning strategies and resources implemented by each school

From the reflective interviews with all three case study schools, it was evident that participants of the study often articulated that after doing the activities in the workshops, they were 'excited' (Appendix XXVI, p. 209) about integrating them into their own planning and teaching, identifying where and how they would be useful. As my diary showed, when participants conveyed their enjoyment and engagement in doing the activities themselves, they also showed enthusiasm for considering where to implement them in their own teaching.

Another important aspect of the global learning in primary science approach workshops and survey was the dual necessity for the security of subject knowledge and up-to-date understanding of global issues

and SDGs. The item of the attitudinal survey 'whilst global perspectives in learning could be important, the concept may need further clarification to be usefully applied to the curriculum' as shown in Table 7.7 below, demonstrates that some stakeholder groups believe that further clarification is needed, whilst others do not.

	Advisors	**SLT**	**HOD**	**Teachers**	**Pre-service**
Whilst global perspectives in learning could be important, the concept may need further clarification to be usefully applied to the science curriculum	17/30 (57%)	0/30 (0%)	10/30 (33%)	14/30 (47%)	12/30 (40%)

Table 7.7 Responses to the statement 'Whilst global perspectives in learning could be important, the concept may need further clarification to be usefully applied to the science curriculum'

Advisors, with 17 respondents agreeing with the statement, had the largest proportion acknowledging the need for further clarification. As this group is influential in changes in initiative, this is an important group to support the development of a clear understanding of the concept. This is especially important as interviews highlighted advisors were more concerned with teachers' security of subject knowledge and may need to be convinced that integrating a global perspective would not deter from this. It was more concerning that 0% of SLT did not identify the need for further clarification. This could suggest a lack of motivation to seek professional learning support related to this area, they may have felt they already understood it, or they may not feel that it is necessary for them as they do not directly deliver the curriculum. Regardless of speculation, it is important to explore the engagement of this stakeholder group, who are pivotal in supporting change. Interestingly, the teacher group included around 50% who agreed that further clarification may be useful, which again may suggest a lack of motivation of the other 50% to explore the approach further. Respondents who took part in the semi-structured interviews did, however, recognise the need for further professional learning related to both core science subject knowledge and knowledge of SDGs and the clarification of global perspectives within, as identified from the semi-structured interviews, a summary of these responses is displayed below in table 7.8.

Table 7.8: Responses in semi-structured interviews identifying professional learning support (from appendix XXXII, p.216)

- We need to ensure our teachers and trainees are up to date and confident with current science and developments.
- Through the support of a specialised science teacher in the school to ensure teachers are kept abreast of new initiatives and developments.
- Confidence with linking SDGS and science National Curriculum subject knowledge

- I agree that teachers and students need to develop a better understanding of the SDGs in order to incorporate them into their teaching.
- Global issues / SDGs are integral to the curriculum – thus giving consultants and ITE providers the impetus to equip teachers with the skills to integrate it.
- There is not enough time to ensure that the teachers have secure knowledge and skills in science to underpin a global approach with links to sustainable development goals.
- Support on how to keep up to date with global issues and current affairs, such as who to follow on twitter
- More ideas about how to realistically develop skills of working scientifically- a global learning perspective which is still practical / enquiry based.

When asked what resources and platforms could be used to support the integration of an approach, there were a wide range of suggested ideas including collaboration, modelling and accessible resources. As will be acknowledged in the discussion Chapter 8, it is evident that a multi-pronged strategy is necessary to support the approach.

Table 7.9 Suggested ways to support the global learning in primary science approach

Resource / platform	**Frequency**
Leadership magazines	1
Sharing good practice / ideas with colleagues	3
National STEM website	2
Science lead who has an excellent bank of knowledge and resources to support the curriculum and beyond.	2
Links and collaboration with university / ITT provider	1
Reach out reporter website – to discuss and keep abreast of science related news around the world (informs both teachers and children)	2
ASE conference ideas and stands with GL ideas	1
Explorify and other resources to develop critical thinking	4
British science week (current focus ‘our diverse planet for 2020)	1

Practical action (practical STEM activities focused on global issues)	3
Tag videos	1
Standing on the shoulders of giants.	1
Water explorers	1
General news (BBC, Guardian, online, CBBC news)	4
Social media (facebook, twitter, instagram)	8
Leicester borough has an eco-education coordinator, encouraging all local schools to get their green flags	1
School national initiatives (fair-trade fortnight, eco club, join the pod)	3
A dedicated Global Learning in Primary Science website	2

7.2.1.3 Providing a framework for planning

The third emerging theme, related to the framework supporting teachers' implementation, considered their involvement in translating the approach into practice. Involvement in their own professional learning related to global learning in primary science, as identified, is key to changes in their professional and personal identities. Guskey (2009:496) refers to involvement as 'active learning experiences' and active involvement in the incorporation of the approach. Insulander et al., (2019) agree that by seeing teachers as proactive experts who structure, explain, challenge and assess children's learning, teacher agency can be achieved. This was evident by using a global learning in primary science framework to scaffold planning, giving teachers the opportunity to be involved in the integration of the approach within their practice, considering how to ask questions, challenge student thinking and identify concrete activities. The framework supported teachers to synthesise global learning PCK (integrating strategies such as critical thinking) with primary science PCK (integrating meaningful scientific enquiry), whilst linking global issues to the formal curriculum programme of study, as outlined below in a science planning overview used by the science lead in school B, figure 7.4.

Science planning overview- School B			
Year Group: 4		Programme of Study: States of matter (Specifically considering how solids, liquids and gases can be separated by sieving, filtering and evaporating)	
Wider Purpose / Global context / SDG lens:	SDG 6 - Clean water and sanitation	**Global Competencies / attitudes developed:**	Collective responsibilities, awareness of global issues, problem-solving
Pedagogical strategies (P4C, critical thinking, OSED, etc):	Critical thinking -What would a world without water be like?	**Meaningful scientific enquiries (Progression of working scientifically skills):**	Which materials help to clean rainwater most effectively? (Comparative test)
Child-led enquiries and application of learning: Designing a water cleaning invention			
Global Competencies: *Understanding different perspectives, collective responsibilities, collaboration and communication, awareness of global issues, problem-solving*. Do you think there are any other ways we could clean the water? How do you know your drinking water is clean?			

Figure 7.4 A science planning overview from school B.

Involvement through group planning sessions brought a range of benefits for Heads of Science and teachers. Firstly, it gave them an opportunity to think critically about the purpose underpinning their science teaching. This also corresponds with Henson's (2002) findings that for professional development programmes to influence teachers' agency, they need to compel teachers to think critically about their classrooms and behave actively in instructional improvement:

> *'It made me feel different about what I was teaching and it felt like the missing link. I spent more time researching ideas and appropriate resources, but I actually enjoyed doing it, as I could see why it was important'*
> (Appendix XXVI, p.209 Reflective interview with Head of Science in case study school B).

> *'Using the framework made me keep global competencies and global issues in mind when I was planning. It made me think more carefully about the type of activities the children would do and how they [the children] would work together'*
> (Appendix XXVI, p.209 Reflective diary case study school C).

And finally, during the global learning in primary science CPD sessions,

> '*Working in groups focusing on a single SDG and how it related to science learning made me realise how many links there were'*

(Reflective diary from ASE January 2020, XVII, p.201).

Although respondents were introduced to a planning framework during the global learning in primary science workshops, all three schools attempted the integration of a global learning approach in different ways. They all, however, described the importance of considering the relationship between science learning and global issues, specifically to consider solutions and responsibilities. Thus, it could be suggested that evaluating and developing schemes of work with underpinning values, offers teachers the opportunity to develop their own curriculum coherence (Myatt, 2018).

Finally, as Priestley et al., (2012) highlighted, the concrete context for action was important to support the achievement of teacher agency. As the head of science from Case Study School A said (Appendix XXVI, p.209), 'if this was proposed a couple of years ago, when our numeracy and literacy progression scores were low, our head teacher wouldn't have been open to a new way of planning, but now we know our scores are good, we have space to be more creative in other subjects'. The head of science from Case Study school B (Appendix XXVI, p.209) had a similar experience: 'I didn't think the SLT was going to be open to the new approach, but when they gave me and the team time to change the planning, I got excited about it'. This, as Priestley et al (2012) highlight, demonstrates how social relationships can support or hinder achievement and should be paid attention to during the professional learning surrounding a new approach such as this. This finding also concurs with the findings of Insulander et al. (2019) who identified that whilst professional development materials that offer guidance and provide different strategies allow scope for agency, we must consider the context in which they are being used. For example, considering the role of middle leaders and mentors working with teams to plan and implement a new approach together.

7.2.2 Chapter Summary

Table 7.10 summarises the professional learning workshop strategies which influenced the case study schools' practice (emerged from reflective interviews, my reflective journal and evidence from teacher planning and children's work).

Table 7.10 Professional Workshop strategies

Theme	Agency dimension	Strategies	Impact	Challenges / further developments
Establishing a shared vision of primary science	Cultural dimension (ideas, values, discourses)	- Drawing on the aims of primary science curriculums around the world to establish common beliefs - Drawing parallels between common beliefs and aspects of a Global Learning approach	Curriculum cohesion Reaffirmation of established 'good' practice Motivation due to developed Community Of Practice (shared passion for improvement)	Meeting expectations of all stakeholders Accountability and assessment beyond teacher assessment framework

Platforms for sharing practice, resources and ideas	Material dimension (environmental and resources)	- Trialling activities and resources in Global Learning workshops - Raising awareness of online platforms through which to access resources and ideas	Trialling resources supported respondents to recognise the links between Global Learning and Science Consideration of how resources could be incorporated into practice proves to be a valuable exercise Highlights gaps in knowledge both in science and in Global issues	More opportunities for the provision of an extended learning environment for continued professional learning about global issues (especially in relation to SDGS) and develop science knowledge.
Providing a framework for the approach	Structural dimension (power, trust and collaboration to change)	- Provision of framework to inform planning - Co-learning with schools to develop a Global Learning in Primary Science approach	Respondents were motivated by group planning, empowered by sharing ideas and developing a new approach as a team – a sense of joint ownership	Resistance from Senior leadership Accountability and assessment – being able to measure impact of change

Table 7.10 draws on the clear relationship between the themes established as influencing change and the dimensions of teacher agency, established by Priestley et al., (2017) in their 'ecological approach' to teacher agency. The initial sections of this chapter consider the iterational and projective dimensions of teacher agency in terms of their beliefs and purposes of primary science education. This section focuses on the practical-evaluative dimensions (namely cultural, structural and material).

When comparing the three schools in relation to the dimensions above, the complex nature of teacher agency is evident. From a cultural dimension, school A was able to include the importance of global citizenship in their Primary Science Quality Mark principles for science (appendix XXVII, p212). Subsequently, with SLT support, a community of practice with a shared vision and discourse related to global learning in science was established. As the science leader acknowledged, all teachers embraced the approach integrating global issues into their planning and knowledge organisers (XXVIII, p.213). For school B, without the initial support of SLT, a shared vision and expectations were evidently harder to achieve, resulting in a science week with a global learning lens rather than broader integration of the approach from the outset. And finally, school C led the global learning workshop without SLT presence but was given dedicated team planning time to embed the approach. This allowed shared expectations and discourse to be established. From a material dimension, all schools identified the need for further support, resources and the need to see the approach in practice. School B and C both articulated that once they had trialled and reflected on the implementation of some of the activities, they were more enthusiastic about embedding the approach into their practice (XXVI, p.209). From a structural dimension, the three schools highlighted both opportunities and constraints in using the approach. For example, school A who were conducting PSQM application had prioritised science in the school development plan, and the science lead had clear strategic actions to support and develop science teaching and learning. Having global issues in science knowledge organisers supported accountability and monitoring of their integration. School C's head of science also established shared expectations for the integration of a global learning approach within their planning, ensuring teaching included critical thinking, SDGs and P4C into their planning (appendix XXX, p.213). School B, after the initial science

week, also included a global learning dimension to their planning framework. Developing a shared vision which incorporated the global dimension clearly supported agency and enabled the establishment of a Community of Practice, described in Chapter one, enabling practitioners to share their passion for global issues (such as climate change and sustainable resources) and learn how to incorporate them more effectively in the science learning.

Secondly, semi-structured interviews and my reflective diary both demonstrate the importance of trialling teaching resources as having potential influence on teachers' agency. Although sharing online platforms was useful, providing respondents with collaborative time to consider the integration of resources and approaches not only enabled them to see their potential in their science lessons, but also aided the development of their own science and global learning knowledge and understanding. Identified themes, such as rainforests or bees, along with structure and support from senior leaders could also be important to guarantee science knowledge and skills were achieved, whilst global issues were motivational and relevant.

Finally, acknowledged in the summary of the three schools above, the culture of the school is fundamental to teacher agency and the successful implementation of the global learning approach. As discussed in Chapter Two, transformative professional development includes the decisions and actions beyond global learning workshops (as identified by Kennedy, 2005). It also recognises the dependence of the unique setting in which it is applied. Described as a meso-level, Chapter Two outlined the multiple factors within school contexts influential on teachers' practice. The use of a framework supported the trialling, teaching and reflection of activities within a school and enabled the head of science to disseminate and support the approach to colleagues. However, it was the collaborative planning that empowered practitioners and enabled joint ownership. Working closely with the researcher in a co-learning partnership provided an additional layer of reflection and accountability but support and collaboration with senior leadership was seen as a significantly motivating factor. Thus, at a meso level, exploring how a global learning in the primary science Community of Practice can be enabled will be essential to the success of this approach.

In relation to this structural dimension, considering how global learning in primary science professional learning can support pre-service teachers and advisors will be paramount to its implementation. Developing a Community of Practice beyond the school context through professional learning networks, and social media needs to be explored further. And this, as becoming increasingly evident, may only be enabled if, at a macro level, the approach is made more explicit in policy.

This chapter's findings stress the complex nature of agency in the successful implementation of professional development related to the global learning in primary science approach including teachers themselves, the context of their school, and the opportunities for collaboration and support. Chapter 8 discusses the findings related to both teacher beliefs and professional development and the extent to which global learning can support primary science education

CHAPTER 8 DISCUSSIONS AND IMPLICATIONS

8.1 Introduction

This study explored the extent to which and ways global learning could be used to develop the purpose and value of science in primary schools. Currently, teachers in England face great challenges in terms of science education: responding to the requirements of delivering the science curriculum and ensuring children meet the age expected 'working scientifically' and content statements set out in the policy framework (Standards and Testing Agency, 2018), whilst finding ways to ensure science learning is meaningful and will enable young people to develop the skills, attitudes and values that they will need in the world they are being confronted with.

Whilst it is essential that teacher training and professional development support trainee and practising teachers to meet the managerial and policy demands, this study is underpinned by the belief that science learning should enable children to develop the global skills and disciplinary knowledge to act in and with the world as global citizen. With an understanding that a teacher's beliefs will influence their agency and motivation to promote learning in line with a global learning approach that supports personal, ethical, cultural and political interests of society (Sterling, 2011; Thomas, 2016; Filho, 2018), this study explored the trends in beliefs of primary practitioners and the opportunities to successfully incorporate such an approach. With a specific focus on practitioner attitudes and beliefs, and the nature and process of subject-specific professional development, this chapter will discuss the findings identified in Chapters 6 and 7 to answer the research questions. Finally, these will be drawn together to consider the extent and ways in which a global learning approach adds value and purpose to primary science education. Themes emerging from the data analysis in Chapter Six and Seven will then be considered alongside relevant literature leading to inform a model and a revised conceptual framework.

Research aims

To answer the overarching research question, and to consider how global learning in the context of science in primary schools in England, the following research questions formed the core of the study:

1. *In what ways do stakeholder beliefs and attitudes to global learning in primary science influence their engagement with the approach?*
2. *How can a global learning approach to primary science be integrated into ITE and professional development?*
3. *How does a global learning pedagogical approach support greater motivation and engagement with the primary science curriculum?*

Chapter two of this thesis explored the significance of pedagogical beliefs on changing practice in primary science education, whilst Chapter three analysed and identified successful elements of professional development in primary science education. The aim of this study was to bring together these two separate constructs (that is, pedagogical beliefs and professional development) to consider how global learning as a pedagogical approach develops primary science teaching and learning. Chapter four brought together the literature from chapters two and three to inform a theoretical framework underpinning a global learning approach to primary science and a related professional development model. Chapter five outlined the methodology which used an embedded mixed-methods approach to explore the beliefs, engagement and motivation of primary education professionals towards a global learning approach to science. Chapters six and seven outlined the findings of the study in relation to beliefs and professional development respectively. Chapter eight, therefore, discusses the findings in relation to literature to respond to the research questions and develop a modified theoretical framework informing the recommendations towards using global learning as a pedagogical approach in primary science education.

8.2 Research Question one: *In what ways do stakeholder beliefs and attitudes to global learning in primary science influence their engagement with the approach?*

KEY POINTS

- Aligning beliefs about primary science education with the principles of global learning promote engagement with the approach.
- Where stakeholders' beliefs and attitudes about the purpose of primary science education do not align with a global learning approach, it is often due to policy frameworks, accountability measures and an understanding of the purpose of primary science being a foundation for future education and careers. Policy frameworks and accountability measures must value learning beyond knowledge and skill acquisition to support changes key stakeholder engagement.
- Creating a global learning in primary science Community of Practice in which stakeholders develop a shared consensus of the global skills underpinning science education will support mutual responsibility, accountability and shared understanding of the approach.

Chapter six explored the relationship between professionals' beliefs and their attitudes towards a global learning approach. The findings presented in this thesis add to the theory concerning the complex relationship between teachers' pedagogical beliefs, attitudes and classroom practice, with a specific focus on science.

In relation to the understanding that beliefs and attitudes influence action (Pajares, 1992), it is affirmative that practitioners hold similar beliefs about the aims of science education to those underpinning the global learning approach. Through developing an understanding of the global learning approach to primary science and drawing parallels with stakeholder beliefs about primary science education, further engagement and motivation towards the approach may be sustained (as

semi-structured interviews revealed). It emerged, however, that other factors may inhibit full engagement with the approach. The following findings relating to specific stakeholder groups support a deeper understanding of how beliefs and attitudes can influence and support the sustainability of the approach.

8.2.1 Advisors

Advisors of primary science had a significantly lower attitudinal value towards the concept of a global learning approach to primary science education than other stakeholder groups. Semi-structured interviews revealed two important factors to consider. Firstly, their views about the purpose of science education were often related to the development of knowledge and skills identified in the National Curriculum (DfE, 2013). This is supported by Webber (2016) who points out that teacher education (both pre-service and in-service) is often conceptualised by curricular outcomes derived from subject-specific standards. This relates to the research Kioupi and Voulvoulis (2019) who found that practitioners of specific disciplines often thought principles related to global issues and sustainable development would be covered elsewhere in the curriculum. From a **macro-level**, policy frameworks which elicit aims and outcomes beyond knowledge and skills will promote and encourage discourse and expectations in professional development and primary science Communities of Practice. Therefore, explicit curriculum aims relating to global learning and sustainable development will be crucial for consistent embedding of the approach into the subject area.

As with any shift in approach, the impact on pupil and school outcomes may need to be evidenced to convince this stakeholder group of its value (DfE, 2017a; Goodall, 2005; Guskey, 2000; Nelson, Spence-Thomas and Taylor, 2015). Furthermore, whilst it is important to consider how to identify and assess the impact of the global learning approach in relation to its underpinning aims, evidence from semi-structured interviews suggest that for advisors to be motivated to engage with a global learning approach to primary science, its positive impact on science knowledge and skills must be evidenced and understood. That said, these findings also suggest that a paradigm shift may be required for advisors to fully embrace a global learning approach, considering a more transformative learning approach to primary science in which learners have space to reflect on their science learning, strengthen their critical and creative thinking capacities and demonstrate initiative, as advocated by Scott (2015). This also relates to critical pedagogy literature in which teacher educators have the challenge of supporting teachers to put their children at the centre of the learning process, considering how the science curriculum they teach relates to the rapidly changing context in which they live, as McLaren (2014) suggests, supporting them become develop responsive teachers delivering active, socially transformative learning experiences.

The findings identified that the advisor group had the greatest number of respondents agreeing that further clarification was needed for the approach to be usefully applied to the curriculum. In agreement with Harrison (2013), practitioners cannot conceptualise innovative practice before they develop it within

their own teaching. This also applied to advisors, who need to conceptualise practice before they 'advise' and disseminate it with others. Evidence from the researcher reflective diary entries of workshops with this stakeholder group evidenced their deep knowledge of the primary science curriculum which allowed them to readily make links between SDGs and science concepts, as well as suggest ways in which critical and creative thinking could be embedded into learning experiences. Advisors who also had roles within the classroom were motivated to trial the approach, having a deep curriculum knowledge and articulated efficacy in making links.

As research indicates, teacher educators can be pivotal when initiating pedagogical reform, sustained by school leadership (Cordingley et al., 2007; Perry, 2017; Timperley et al., 2008). Providing advisors with the opportunity to conceptualise a global learning approach to primary science through activities which enable them to design and deliver professional development in line with a global learning approach should be encouraged. This may not only challenge teacher educator beliefs, but it may support the operationalisation of a global learning approach. This agrees with Stoll et al.'s (2012) notion that effective professional learning involves external experts supporting teachers to connect theory and practice. Although not within the scope of this study, exploring the impact of advisors trialling a global learning approach in the classroom on the content of their professional development with pre- and post-service teachers would add further insight into the role of advisors in actualising a global learning approach.

In summary, providing advisors the opportunity to consider the global learning in primary science approach and its impact on teaching and learning could be key to successful implementation. Ultimately, advisors need to sustain dialogue with the primary science community about the values and purpose of science education which moves beyond a list of attainment descriptors. It could be argued, therefore, that at a **micro-level**, advisors of primary science should be supported to trial new approaches to reflect on and evidence the impact on knowledge and skill development. Nind and Lewthwaite (2018), for example, highlight the benefit of working alongside teachers and learners, not only to support a deeper understanding of pedagogical content knowledge, approaches and strategies, but to identify the impact on learner and teacher attitudes.

8.2.2 Senior Leadership Team (from a meso-level of analysis)

As well as advisors, the attitudinal value of SLT members was lower than the other groups, with a low percentage of this group wishing to pursue further professional development related to global learning in primary science. As identified in Chapter 3, science-specific professional development is not often a priority for SLT, and consequently does not always feature in the school's development plan. As demonstrated through the case study schools, and in previous research (Seiser, 2019; Nelson, Spence-Thomas and Taylor, 2015), heads of science in schools identify that SLT and whole school support are imperative for any successful implementation of a new pedagogic approach. This finding is supported by the work of Biesta et al., (2015), agreeing that the mismatch between teachers' individual beliefs

and values and the wider institutional discourse and culture can inhibit teacher agency. Subsequently, **from a meso level**, as supported by Bennell (2015), SLT supporting and enabling professional learning and collaborative practice is not only crucial to initial motivation and engagement with the global learning approach but can facilitate a deeper understanding of an approach through the cyclic process of planning, implementing and evaluating in relation to student learning (Seiser, 2019).

Levinsson (2013) and Timperley (2008) underscore the emphasis of achievements and results as highly influential in terms of discourse and measure of success within a school. Evidence from the case study schools indicated that only when a school was achieving well in national performance tables, were they open to new initiatives, such as the global learning approach to primary science (especially when they did not focus on English or mathematics). Not only are performance tables seen as a direct judgement of the quality of teaching within a school, but they are a form of accountability in the local community, regardless of purposes and processes being measured, as Reed (2003) points out. It could be argued that even if SLT members supported the global learning in primary science approach in terms of initial training and implementation, the less measurable impacts (on global skills) may translate into low SLT prioritisation. They are more likely to prioritise initiatives that show measurable improvements in attainment, due to time and money constraints, as well as accountability pressures, especially by inspection bodies. As identified above, further research is required exploring the impact of a global learning approach on science knowledge and skills, as well as the wider purpose of a global learning approach can be evidenced.

That said, the three case study schools which trialled the global learning approach all had school visions which identified the importance of innovation, empowerment and 'dreaming big'. Motivational and enthusiastic head teachers and SLT members from these schools, as evidenced in semi-structured interviews, valued the importance of nurturing children as global citizens. Whilst improving performance and accountability measures remains a priority, the evidence from the case study schools suggests that subject-specific initiatives that align with a school's ethos are welcomed more readily when a school is in a 'good place' in high-stake accountability measures. Again, as Biesta et al., (2015) suggest, having school values (such as respect, fairness, personal and social responsibility, integrity and self-awareness) which frame the wider purpose of education, may support professional development which looks beyond policy agendas and short-term goals.

8.2.3 Knowledge and skills versus attitudes and values

Beliefs about the envisaged benefits of global learning in primary science often related to attitudes and behaviours rather than knowledge and skills. Whilst the overall aim of global learning in primary science is to foster the role of science in nurturing and empowering global citizens (requiring a paradigm shift as discussed above), making links between the approach and statutory attainment measures may be important to initiate engagement. As Gore et al., (2017) highlight, professional development is often

driven by greater levels of accountability and improved pupil performance, which are often measured by attainment measures.

The case study schools all highlighted the positive impact of the approach on engagement in primary science lessons. Considering how to translate the potential impact on knowledge into long-term memory and skill progression through meaningful enquiry and relevance (as well as positive impact on other subject areas) may also provide an opportunity to engage more professionals in the approach from the outset. Findings from neuroscientist Howard-Jones (2018) discuss the complex relationship between engagement and learning. They illustrate that having the opportunity to recall and apply freshly learnt knowledge (in low-risk situations which do not involve exams and formal assessment) helps knowledge to be more easily retrieved in the future. An area of future enquiry, therefore, needs to look at the impact of the global learning approach on the progression of science knowledge and working scientifically skills, with a focus on engagement, retrieval and application to problem-solving activities.

8.2.4 Agents of change

Biesta et al., (2015) underscore how teacher agency is highly dependent on personal qualities of teachers (including their beliefs and values). When exploring the attitudes and values that practitioners considered important aspects of science learning, it was evident that these often aligned with the attitudes and values identified in the global learning approach (for example. being active participants in scientific enquiry, taking responsible action and understanding the consequences of their actions). However, teachers are driven by goals in their work, which often focus on the immediate attainment outcomes rather than long term significance and process of nurturing global citizens. Enabling practitioners and schools to work together to establish a shared consensus of attitudes and values underpinning their science education in relation to a global learning approach is, therefore, essential to its success. As Kioupi and Voulvoulis (2019) advocate, allowing practitioners to develop a shared understanding of global learning and identifying sustainable development as a purpose of science education, is critical to the design and delivery of a global learning approach to primary science education. Reflections from the three case study schools confirmed that a shared understanding of the global learning approach supported teachers to celebrate learning beyond the National Curriculum objectives (DfE, 2013).

As acknowledged by Alvunger (2018), teachers personal ideals and principles are often compromised in the face of educational goals that standardised teaching content and assessment. Bergh and Wahlström (2017) agree that a national curriculum framework creates a dilemma for teachers in terms of being a practical system for knowledge checks and controls, but also shaping their teaching in terms of an overall nature and purpose of the subject. This study has identified the importance of a space for teachers to collaborate to frame the curriculum in relation to the wider aims of a global learning approach. Salminen and Annevirta (2016) go on to emphasise the importance of teachers' participation in curriculum innovation processes in how they engage with a curriculum. Allowing teachers time and

space to collectively tackle the knowledge requirements of the curriculum through a global learning planning framework, could support teacher agency, as Priestley's (2012) ecological framework for teacher agency suggests, which is summarised in table 8.1, below in accordance with the findings of this study.

Table 8.1. Supporting teachers as change agents using the global learning approach

Construct	Professional development strategy
Individual	Eliciting how teacher beliefs about the purpose of primary science align with those of a global learning approach; Providing an opportunity for teachers to trial and adapt global learning pedagogies before integrating them to their own practice; Providing opportunities for teachers to reflect on their teaching, conceptualising global learning in relation to their own practice; Allowing teachers to research ideas, develop resources and develop schemes of work in relation to their class interests and their own learning as global learners.
Structural	Senior leadership team support through action plans, a shared vision about a global learning approach that sets expectations and scaffolds related discourse; A revised planning framework embedding a global learning approach into science curricula providing accountability; Time and space for collaboration to share themes, ideas and best practice related to global learning in primary science; Structures developed ensuring a continuum between school and home learning; supporting an understanding of science and its personal and societal value.
Material	Online and expert support relating global learning to the National Curriculum programmes of study; Evidence of how global learning approach to primary science positively impacts children's attainment / engagement; A resource platform to support teacher's understanding of global learning, as well as provide them with lesson ideas and materials to deliver a global learning dimension to their science lessons.

As articulated by Grice (2019), a shift in pedagogy requires mutual responsibility. From a **meso-level**, the case studies demonstrate the importance of school culture enabling (or constraining) changes to pedagogical approaches. Goodwin (2017) points out that subject leadership in schools is often distributed to middle leaders who actively connect, interpret and translate policy and practice. The outcomes of this study suggest that whilst science subject leaders are pivotal in operationalising a global learning approach to primary science, senior leadership support was vital in providing trusting professional learning environments where teachers could experiment with new approaches. Grice (2019) argues that through enabling teachers to collaborate and establish a collective vision, teachers become motivated and committed as pedagogical leaders and change agents, rather than reduced to facilitating and delivering outcomes of the science curriculum, as Biesta (2015) warns.

To summarise, given the current nature of primary science, whilst positive beliefs and attitudes towards global learning in primary science are evident, for global learning to be valued as a vehicle to raise the

quality of teaching and learning in primary science, factors such as time, senior leadership support, accountability measures and resources from subject-specific experts need to be considered. Supporting trainee teachers and practitioners to consider the wider purposes of science education through robust professional discourse is also important. This can be seen succinctly in relation to Priestley's model (Table 8.2 above). The next section will explore how professional development and ITE can cater for some of these challenges.

8.3 **Research Question Two**: *How can a global learning approach to primary science be integrated into ITE and professional development?*

Key Points

- Embedding sustainable development and global learning into the ITE framework and teacher standards will inform ITE module guidance and subject-specific teaching and assessment.
- Attitudes and values should be made explicit in national policy and assessment frameworks to drive pedagogical changes and accountability in relation to embedding the approach, supporting the development of global learning PCK within science ITE and professional learning.
- Using SDGs provides a structured framework to support the integration of global issues within primary science, which need to be embedded in ITE.
- Schools and teachers should be nurtured as professional agents of change, with the skills and confidence to make decisions about the context of science learning that suits the needs of their global learners.
- Whole school and SLT support provide motivation, accountability and shared expectations of related practice in primary science teaching and learning.
- A planning framework provides a mechanism for consistent and sustainable integration of a global learning approach.

8.3.1 Initial Teacher Education

The findings of this study indicate that pre-service teachers had the highest value in relation to their attitudes toward global learning in primary science, and the greatest percentage with the desire to pursue further related professional learning. It is, however, evident through my reflective diary and sample recruitment that due to the intensity of their teacher training programmes, engagement of initiatives outside of their assessed module content was a challenge. Zeichner (2006a) concurs that current accountability systems in ITE could eventually lead to teacher education programmes that are only capable of transmitting content knowledge. In agreement with Greenwood (2010), for future development, a vision of teacher education must embrace the complex realities of a changing planet. As advocated by Kioupi and Voulvoulis (2019) and UNESCO (2014), meaningful teacher training programmes are needed that will enable teachers and university lecturers to develop the knowledge, skills and confidence to support an education for sustainable development.

Sterling (2011) proposed a framework for sustainable development within higher education in general, highlighting the importance of embedding it in modules, integrating it into the university culture, linking it to employment and enterprise, as well as making links between sustainability initiatives and learning in the wider community. This research also demonstrates that this would be beneficial within the context of ITE. Through my own practice in teacher education, it is evident that current practices in primary science education within ITE, focus on developing efficacy in delivering the curriculum programmes of study without critical engagement as curriculum agents. There is also an emphasis on making links between subject-specific teacher training and the National Teacher Standards framework (DfE, 2011), which are identified in module guidelines and subject-specific assessments. As these are a requirement of the ITE framework (Ofsted, 2020), this will apply to all ITE programs in England. Not only do teacher standards provide a common language for discussing and demonstrating good practice to possible employers but they also bridge theory and practice. At a **macro level,** a recommendation for consistent integration of a global learning approach to science would be to include a statement in the teacher standards as well as the primary science programmes of study. Specifically, the SDG target 4.7, support 'all learners acquire knowledge and skills needed to promote sustainable development' could be identified in the teacher standards. This would enable teacher educators to ensure this dimension of learning is accounted for, and not left to chance.

8.3.2 A pedagogical dichotomy

As discussed in the response to the first research question, whist all stakeholders have a positive attitude towards global learning in primary science, its identification within the curriculum itself is implicit. The National Curriculum in England (DfE, 2013:168) states that science education should:

> *Provide the foundations for understanding the world through the specific disciplines of biology, chemistry and physics. Science has changed our lives and is vital to the world's future prosperity, and all pupils should be taught essential aspects of the knowledge, methods, processes and uses of science.*

Whilst the importance of teaching scientific knowledge and methods is explicit within this statement, the teaching of skills and competencies to support global development can only be inferred. Some documentation, such as the CBI's survey report on education and learning for the modern world (CBI, 2019), and OECD's Learning Framework 2030 (OECD, 2018a) highlights the importance of creativity, originality, problem-solving and the ability to learn for our future society. Unfortunately, due to their relationship with accountability and school improvement (and even teacher effectiveness), national policy and assessment frameworks often take priority. This is evident in the engagement of all stakeholders in this study.

The OECD framework 2030 (OECD, 2018a: 5) highlights that not only knowledge and skill development are important, but specific attitudes and values are needed to guide young people towards responsible

actions, such as ‘respect for life and human dignity, and respect for the environment’. As the director of the OECD Directorate for Education and Skills stated:

> *Education is no longer about teaching students something alone; it is more important to be teaching them to develop a reliable compass and the navigation tools to find their own way in a world that is increasingly complex, volatile and uncertain. Our imagination, awareness, knowledge, skills and, most important, our common values, intellectual and moral maturity, and sense of responsibility is what will guide us for the world to become a better place (Schleicher, 2019: 5).*

Whilst respondents identified attitudes and values aligned to a global learning approach, it could be argued that until they are made explicit within national policy and assessment frameworks, their translation into science teaching and learning will continue to be left to chance.

At a **macro level of analysis,** this study suggests that science education policy and curriculum frameworks, which guide teacher training and professional development, must overcome a potential dichotomy between the development of subject knowledge and skills and the development of values, attitudes and competencies such as those mentioned above (and their related pedagogies). Along with Roberts (2009) and McGregor (2019), this research demonstrates that there are opportunities to embed creative and critical thinking within science learning and inquiry, ensuring trainee teachers and practicing teachers have support to do so. Using global learning in primary science as a supporting framework in ITE and professional development, teachers could be supported to ensure that children are equipped with foundational knowledge and skills and competencies to develop ‘learner agency’ (OECD, 2018a:4) who are best prepared for the global future. This will be discussed further in the next research question in relation to teacher training and professional development.

It became clear that advisors within this study prioritised security of teacher subject knowledge and their ability to confidently teach through enquiry, as indicated in the policy framework (DfE, 2013:3). Whilst understanding the pressures of supporting pre-service teachers and schools to meet the teacher assessment framework descriptors reliably and confidently, this study argues that there is a missed opportunity to nurture and engage practitioners (and children) through a more creative, holistic approach to science learning.

Although both trainee teachers and practising teachers were enthusiastic about the initial concept of global learning in primary science, sustained engagement with the professional development opportunities was much more sporadic, as findings show. If the goal of the professional learning is to change teachers’ beliefs, evidence suggests that long-term professional development is more likely to promote such a change (Levin and Wadmany 2005). For example, a long-term professional development programme that builds on trainee and experienced teachers’ existing beliefs and practices and is reinforced through on-going enquiry, may offer a promising approach (Sang et al., 2012). This approach is in line with recommendations from other researchers who stress the importance of professional learning as an iterative process, aimed at extending and updating the professional

knowledge and beliefs of teachers in the context of their work (for example, Kopcha 2010; Tondeur et al., 2016).

At **a macro level**, professional development and ITE has an opportunity to encourage a globally responsive pedagogical framework in which teachers are supported to plan, reflect and develop a science curriculum relevant to their learners, informed by current global issues and guided through mentoring and communities of practice.

8.3.3 Using SDGs as a framework to support global learning in primary science

Through the global learning approach in the workshops and case study schools, it was evident that in general, stakeholders had limited awareness of the SDGs. It was, however, marked through activities in the workshops and reflections of planning that practitioners began to realise how many links there were between primary science and the SDGs. Further to this, the reflections demonstrated that some teachers were already embedding many issues and ideas related to SDGs into their science teaching inadvertently (as highlighted in the findings in Chapter 7). It could be suggested, therefore, that supporting teachers and trainees to have a deeper awareness of SDGs would enable them to make conscious links in their science planning and ensure a more systematic approach to their integration (whilst having professional autonomy and confidence to choose SDGs relevant to themes and contexts relevant to their learners).

Kioupi and Voulvoulis (2019) agree that SDGs provide a framework for education allowing children to think, act and relate their learning to the world around them. However, they argue that a systematic framework is required to connect SDGs to educational outcomes. As a teacher educator, reflective diaries demonstrated a passion towards issues such as equality, climate change and biodiversity in trainee teachers. Two recommendations are worth highlighting here. From **a meso-level**, one is the importance of embedding SDGs into teacher training programmes, enabling them to provide meaningful and purposeful contexts for their science teaching. Second, as recommended by Bond (2010), trainees should be supported to develop skills of leadership, defined as ‘making happen what you believe in’. Whilst others argue that this is not the role of a trainee, Bond highlights that pedagogical leadership is about influencing others to do things they would not ordinarily consider.

Evidence from the three case study schools revealed the enthusiasm of teachers to implement a global learning approach into their science teaching through themes which they cared about, such as deforestation, water sustainability and climate change. Within my role as a teacher educator, opportunities within other areas of programme in which the trainees were able to collaborate and choose global issues as a platform for planning and teaching, resulted in high quality engagement and enthusiasm. In summary, having the knowledge and confidence to experiment with a global learning approach in science may enable new teachers and teaching teams to convince SLT of the benefits in

engaging learners with meaningful global contexts whilst delivering the science programmes of study effectively.

Bamber et al., (2018) go on to advise that schools, teachers and children need to have some autonomy in deciding their focus. I would argue SDGs provide a framework to guide their focus, driving the **intent** of primary science curriculum, placing human rights, values, human responsibility, sustainability and wellbeing at the heart of learning, things often already there but not necessarily linked or explicit. Bamber (2018, 2020) advocates SDGs as an empowering form of professional development for teachers. In agreement, the case study school reflections demonstrate that teachers were motivated by researching and developing a deeper understanding of global issues related to science. As Bamber (2018:13) argues, a global learning approach may provide an 'intergenerational partnership' in which teachers, parents and children can engage with science as a life-long learning process.

As discovered with the case study schools, when time and space were given for practitioners to conduct collaborative planning, a strategy advocated by Stoll et al., (2012)., incorporating global learning and SDGs into science schemes of work were both motivating and empowering, Professional development workshops equally illustrated the same impact; a realisation that links between science and sustainable development were authentic and purposeful. Furthermore, in agreement with Cordingley et al., (2003), science leaders in the case study schools indicated that collaboration encouraged teachers to try the new global themes and supported a commitment to changing practice.

8.3.4 The importance of a planning framework

The findings from the semi-structured interviews indicated the concern that core science knowledge and skills may be diluted with the integration of a global learning approach. As Harlen's (2015) 'Working with Big Ideas' document underscores, ensuring that teachers and other stakeholders recognise the importance of core science ideas and an inquiry-based approach to learn these, is fundamental to making informed decisions about the application of science. The reflections from the case study schools illustrated that using planning frameworks and knowledge organisers, science knowledge and enquiry skills remained central to planning and assessment. Sims (2020:28) concurs that the use of 'mechanisms' in professional development in which teachers can exercise agency within the constraints of a curriculum framework, was an effective tool of professional development.

It was apparent from the case study schools and reflective diaries that practitioners responded positively to readily available resources, online platforms and strategies that they could readily use. Further to this, the opportunity within professional development sessions for practitioners to try out the resources and strategies enabled them to envisage how they would work within the classroom. Redman et al., (2018) agree that modelling and trialling resources and strategies in line with an approach, rather than over-theoretical content, may provide teachers with the self-efficacy and motivation to initiate this approach within the classroom. Sims (2020), however, warns that sharing examples of activities and

materials may not be sufficient for school leaders and policy makers to embed a global learning approach. Whilst the findings of this study do not extend to identifying how embedded the global learning approach was within each school's science curricula, in agreement with Sims (2020), a framework is essential as a mechanism allowing the global learning approach to be sustainable.

Finally, the initial success of the professional development seemed to be indicated as teachers strengthened their intentions to research and integrate a global lens to their science teaching, motivated as agents of change. As all stakeholders identified a need for further clarification of global learning in relation to science education, ensuring ITE and professional development provides a platform for a professional learning culture is important for the success of the approach. Professional development, as research suggests, must initiate professionals into a global learning Community of Practice (COP) in which best practice, resources, collaboration, and modelled ideas can be shared (Lave and Wenger, 1998).

8.4 Research Question three: *How does a global learning pedagogical approach support greater motivation and engagement with the primary science curriculum?*

Key points

- Teachers and schools in this study were enthused by the global learning in primary science approach and were empowered by developing an understanding of the purpose of science learning beyond achieving security in attainment descriptors.
- Successful engagement and motivation require a balance of autonomy to make decisions related to context and learner relevance alongside a platform of supporting ideas, links, themes and resources as a starting point.
- The use of pedagogical strategies in line with the global learning approach (such as philosophy for children, OSDE, critical and creative thinking, enhanced opportunities for purposeful scientific enquiry.

The case study schools that embraced the global learning approach to primary science provide an initial understanding of how beliefs and professional development can challenge teachers' pedagogical approach to primary science. It was clear that developing an understanding of global learning pedagogical strategies and the links between primary science and SDGs gave practitioners the confidence to begin planning science with a global learning lens. It was also identified that teachers valued support with ideas of themes and global contexts in which to teach science schemes of work with a global learning lens. However, teachers conveyed their enjoyment and enthusiasm in having autonomy in identifying their own themes and activities in which to deliver the science programmes of study, integrating critical and creative thinking activities, supporting children to reflect on their own perspective and that of others, considering relevant global issues. This idea is supported by Crome and Cise (2020) who highlight the link between autonomy in exercising professional expertise and beliefs and teacher wellbeing.

Within the case study schools, ownership evidently gave teachers agency in delivering a more purposeful science curriculum. However, what was most significant in this study's findings was the important role of colleagues in the implementation of the global learning approach. Research concerning professional learning communities and collective agency, as defined by Harris et al., (2018), may enable a greater understanding of what facilitates a global learning approach to primary science. For example, when SLT members valued the importance of SDGs and encouraged their presence within the science curriculum knowledge organisers, teachers were more likely to embrace, research and integrate them into their planning. Equally, when teachers had a shared vision for science along with a shared language and expectations of what global learning in primary science looked like, motivation was sustained. Individual teacher agency to make small changes in their science teaching within the boundaries of their classrooms was evident through reflective discussions. However, thriving as a teacher necessitates a safety net of collegiality. Biesta, Priestley and Robinson (2015) support the finding that the collective discourses that inform teachers' perceptions, judgements and decision making were clear in motivating teachers to take risks in their science teaching and learning. Promoting teacher agency to embrace a global learning approach to primary science education, therefore, requires more than a shift in beliefs about the purpose and pedagogy of primary science. Collective development and consideration within the school and wider professional community is essential for sustained change. Within this study, social media platforms were a powerful source of sharing and modelling of ideas and activities.

It was evident that teachers in the three case study schools were motivated by the autonomy of choosing and researching global ideas and themes through which to teach their science programmes of study, acting as agents as change. There were, however, some teachers who found it more challenging to embed the global learning approach despite wishing to do so (due to time, limited understanding of the SDGs, collaboration and appropriate resources). It is apparent, therefore, that despite giving teachers professional autonomy to deliver science schemes of work, some expert guidance and support may also ensure appropriate themes related to programmes of study and the development of scientific knowledge and skills. As advisors agreed (and is evident in my own practice as a teacher educator), without security of subject knowledge and knowledge of global issues, quality of both constructs may be lost. Some top-down support may facilitate advisors and SLTs to deliver quality science learning through well thought-out global themes, whilst a bottom-up agency may empower creativity and relevant learning experiences. From a macro perspective, being more explicit in policy (specifically, in the National Curriculum aims, the teacher standards and science programmes of study) will inform ITE and CPD provision, supporting a more consistent and unified approach, rather than being left to chance. Resultantly, identification in policy will lead to the time, space, SLT support and ITE integration and the awareness of global learning pedagogy, knowledge and professional discourse required to operationalise the approach.

8.5 Chapter summary

This thesis reflects the current political climate in which the emphasis lies on teachers and children meeting national-mandated outcomes and skills rather than personal growth, holistic learning, communal responsibility, where success is less tangible and amenable to measure. The outcomes of this study contribute a new subject-specific lens considering the role of global learning in primary science education. The study demonstrates the importance of maintaining the integrity of subject-specific knowledge without compromising its wider purpose for our future global citizens.

What is evident from all stakeholders is the resistance to embrace a new approach that may either be too overwhelming to deliver, too time consuming or a bolt on to an already full curriculum. Making and modelling the links explicit to the science curriculum framework, practitioner beliefs and practices may support and reassure more reluctant practitioners. It is also apparent that to be operationalised, the global learning approach needs to be translated into pedagogical content knowledge, such as modelling critical thinking, creative thinking and philosophy for learning within the context of science. The interface between science subject knowledge and global learning pedagogical strategies will be paramount for its success. The final chapter will conclude by drawing the recommendations from this chapter together, identifying limitations and areas for future research.

CHAPTER 9 CONCLUSION

9.1 Introduction

The aim of this thesis was to explore the ways and extent to which a global learning pedagogical approach could be used to develop the purpose and value of primary science education. This final chapter aims to summarise the research considering the new knowledge and insights which I have detailed in this thesis, and how they apply to my practice as a teacher educator and facilitator of professional development in primary science education. As this thesis demonstrates the complex relationship between practitioner beliefs and pedagogical practice in primary science education, the final section outlines further research questions that are imperative for the future development of a primary science education fit for global citizens.

9.2 Summary reflection on the study and its implications

9.2.1 Macro-level implications and recommendations

This thesis was underpinned by a belief that a global learning pedagogical approach would support a more purposeful and valued primary science education. It is evident from this research that if a global learning approach is to become integral to primary science education, the underpinning aims should be made explicit within the primary science policy framework. As well as an overarching aim of the primary science curriculum being 'act responsibly and make informed decisions using scientific knowledge and skills', a recommendation would be for programmes of study to make direct links to global issues. Not only will this drive professional discourse and expectations (Bell, 2006), but it will ensure a consistent and guided approach across schools. Young (2014) highlights the importance of the curriculum in providing a framework for 'powerful knowledge', guided by the underpinning aims and purposes to enable children to critically consider scientific knowledge as global citizens. Further to this, identifying sustainability and the wider purpose of learning within the ITE framework will ensure that global learning pedagogical approaches are developed through training. A recommendation is to translate the UN Sustainable Development Goals into a guiding framework for ITE. This will ensure that trainee teachers are confident in their knowledge of global issues, related pedagogical content knowledge and their confidence to embed its relevance to science-specific curricula.

In line with the dynamic nature of science (Lederman, 2013) and the continually evolving global issues and challenges, ensuring science teaching and learning is supportive future global citizens must involve sustained and on-going subject-specific professional learning. This will require a deeper consideration of platforms and tools to ensure professional discourse focuses on long-term purpose as well as short-term goals.

9.2.2 Meso-level implications and recommendations

A further implication is the importance of collective agency and the role of different stakeholders. This research suggests that if advisors are to engage with the global learning approach, facilitating collaboration and a shared understanding of the purpose of primary science is key to building common discourse, expectations and accountability, supporting its success and implementation (**a community of practice**). Facilitators of science-specific professional development like myself must gain an awareness of a school's priorities and ethos as a starting point to initiate engagement beyond accountability measures and begin to support curriculum coherence.

In order to embed a global learning approach into any school's practice, a shared understanding is required. Not only can this be solidified by aligning a global learning approach with school values and ethos, as well as the science-specific principles, but it can be enhanced by celebrating the relevance of science learning to the wider world through blended-learning home activities and links with the local and global community. Senior Leadership Teams and science subject leaders both have a role to play in operationalising a global approach through providing space and opportunities to share best practice, collaboration and shared responsibility.

It became increasingly apparent through the research process that amongst the stakeholders, very little was known about global learning as an approach and the related SDGs that guide sustainable development within the primary education community. Whilst research and literature around efforts to embed global issues across the curriculum are increasing, there is very little published research into how sustainable development and global learning are conceived by teachers and learners within primary science education. Teacher training programmes, like my own, have a role in developing related knowledge and pedagogy.

Within teacher training programmes, along with development and security of science knowledge related to the curriculum, it is recommended that trainees should be given the opportunity to develop a secure knowledge of SDGs in order to embed them in their teaching with autonomy. Nurturing a personal commitment to learning about both science and global issues within ITE and CPD will support professionals themselves as global learners and their ongoing commitment to a global learning approach.

It has been a key finding of this study that the driving force for change was a personal commitment from individuals within each case study school who were responsible for the initial implementation of the approach, using a planning framework to support others. Like PSTT and PSQM models discussed in Chapter 2, supporting leaders of primary science within schools as global learning champions with continued expert and community support, can enable a bottom-up approach. A professional development model in which these people are considered as leaders or change agents for sustainability

within primary science in their schools is more likely to result in an embedded shift and whole school commitment to a changing approach.

9.2.3 Micro-level implications and recommendations

The individual stakeholder, whether that be the head teacher, the consultant or the teacher, may need to make a personal paradigm shift about the purpose of primary science education in order to embrace in a global learning approach. Ensuring that practitioners are supported to invest in the on-going development of science-specific subject knowledge and global issues, as well as science and global learning related pedagogical strategies will be fundamental for successful implementation. A motivation to trial a global learning approach may enable practitioners (from advisors to trainee-teachers) to conceptualise the approach and observe impact on the learner.

At a micro level, the findings suggest that supporting teachers to make links between their beliefs about primary science education and the aims of global learning have an influence on their engagement with the approach. In line with Vygotsky's social constructivism, learning is a social activity and a collegial one within a school, thus the strategy of developing a shared vision for science education beyond programmes of study is a key recommendation (developing **a community of practice**), whilst enabling individuals to reflect on and develop their own beliefs about science education and their role beyond curriculum delivery (**a personal commitment**).

The study's findings also suggest that providing teachers with opportunities to trial and experiment with global learning strategies in their science teaching, allowing them to reflect and share activities, result in increased motivation and confidence, and shifting beliefs and subsequent practice. Providing opportunities for advisors to trial and design global learning science activities is also an important recommendation. A misguided belief that a global learning approach may dilute science-specific learning must be mitigated through providing a clear framework in which global learning directly links to science programmes of study and maintains subject integrity, such as the one recommended in this study. In other words, as Harrison (2013) suggests, the action of designing and teaching can support the conceptualisation of the global learning approach in relation to primary science (**a paradigm shift**).

Another implication relates to the importance of evidencing the impact of a change in pedagogical practice on pupil outcomes. Whilst this study did not extend to following the evidence on children's learning, it was clear from this study and the literature review that professional development is most successful when it is directly related to learning outcomes. In further professional development, providing opportunities for advisors, teachers and students to trial and reflect on how a global learning approach to science lessons impact on science knowledge and skill development, as well as attitudes and competencies, will enable the engagement, sustainability and development of this approach within professional development and teacher training (**developing pedagogical content knowledge**).

9.2 Contribution of learning to theory

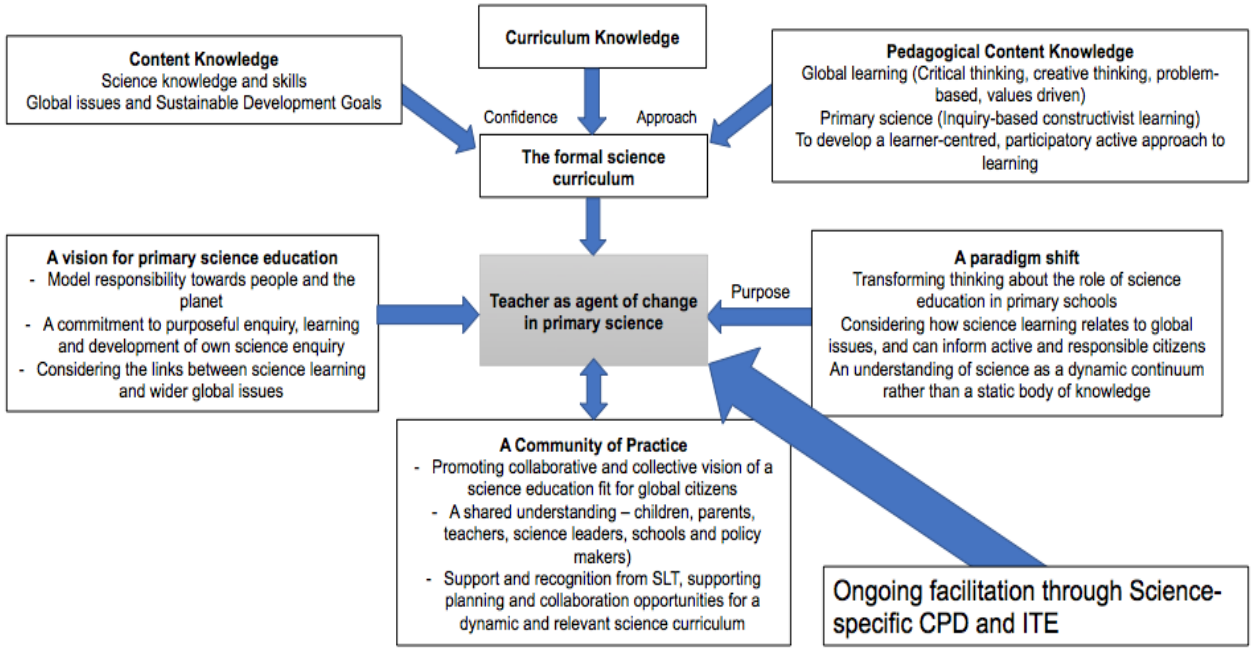
In summary of the recommendations outlined above, in order for practitioners to be supported as agents of change who support children to think and act as responsible, scientifically global citizens, ITE and professional development in primary science needs to be reconsidered.

Consequently, this requires:

1. Pedagogical strategies to be integrated into science planning and teaching in line with a global learning approach;
2. A shift from focusing on knowledge and skill outcomes, to application and problem-solving, with the use of science knowledge and skills;
3. Policy frameworks to elicit the importance of global learning as integral to science education.

To summarise these findings, recommendations are outlined below with a revised model and framework synthesising these concepts.

Figure 9.1: A Theoretical model and framework for recommendations of a global learning in primary science approach



Although the framework above focused on primary science education, the model could be applied to other subject areas. Subject-specific teacher education and Continued Professional Development must support Schleicher (2014) who believes that educational success is no longer about reproducing content knowledge, but about extrapolating from what we know and applying that knowledge to novel situations.

9.3 The impact on my own practice

Throughout this thesis, I have made it clear my own belief of the importance of global learning as being fundamental to raise the profile and value of primary science education, whilst operationalising SDGs. My research focused on the professional development and training that supported the implementation of a global learning approach, with the consideration of the beliefs and motivations needed to employ a change in approach. However, to bring about such change, enablers and barriers across micro, meso and macro levels, as outlined above, needed to be considered.

In reality, the biggest impact of the Education Doctorate journey has been on my own thinking, allowing me to explore the complexity of stakeholder influences and to critically consider my own agency in the primary science community. It has enabled me to expand my professional network, researching at the interface of professionals who work in primary science and those who work in global education.

I would argue that as professionals, we need to continually examine our agency, how it is constrained and framed by contextual factors, including political frameworks and related discourse. Completing an Educational Doctorate has given me the opportunity to examine the opportunities and barriers as an agent of change. It is important to seek coherence and view tensions in education systems as opportunities for change and development, rather than as barriers. Developing this mindset has the potential to allow me to continue to explore possibilities in the future challenges within primary science education.

My thesis recognised that whilst it is easier to implement the global learning approach in schools which already address sustainability issues, this may not lead to embedded change. In a similar manner to institutional demands of the awareness and integration of equity and diversity in learning, I believe the same should be applied to sustainable development and global learning – becoming mainstream and as an expected outcome of science learning.

9.4 Limitations

There are several limitations of this study that are important to note. Firstly, the research did not seek out the perspectives of the learners of primary science. This may have contributed to the findings in a significant way by adding more clarity in the ways in which the global learning approach could raise the value of primary science education. However, as highlighted in the introduction, the concern underpinning this study was how to support and engage the stakeholders who influence the approach to primary science education.

Participatory action research can be defined as an approach to research that emphasises participation and action, seeking to understand the world by trying to change it, collaboratively and following reflection (Reason and Bradbury, 2007). Whilst the study involved following up science schemes of work, samples of children's work and reflective interviews with teachers from the case study schools,

the study did not extend to observing science teaching and learning. Considering the implementation and influence of a global learning pedagogical approach through drawing together strategies such as philosophy for children, critical and creative thinking, innovation and responsible action is an important aspect of sustained pedagogical change and will be an area of future research. However, considering how children and teachers engage with the new approach, and the subsequent impact on their learning and achievement is fundamental in terms of informing future professional development and engagement.

Methodologically, there are other limitations to mention. Insider research requires the researcher to look carefully at one's own experiences, values and beliefs, and question the impact of these on the research design, data collection, interpretation and presentation of data (Gregory, 2017). Whilst my own professional autobiography will have had an impact on the research validity (Patton, 2012), adopting a level of reflexivity to mitigate the impact of this was conducted through a transparent approach, piloting of the design and regular meetings with my supervisor to reflect at each stage of the research. Subsequently, the benefits of insider researcher outweigh the limitations, enabling me to gain a deeper level of understanding and interpretation (Fleming, 2018).

9.4.1 Recruitment

Recruiting enough individuals and schools for both the survey, semi-structured interviews and the subsequent professional development and implementation was not without challenge. However, this has become an object of methodological interest. Whilst pre-service teachers and practicing teachers showed initial interest in the approach, the requirement of a time commitment and school community commitment to pursue training and a change in approach was less attractive. This demonstrated the vulnerability of the construct, overtaken by assessment or accountability measures. This is supported by Paige and Hardy (2019) who confirm that teachers are often seen to abandon adventurous pedagogic practices in order to concentrate on curriculum coverage and assessment preparation.

Supporting teachers (and pre-service teachers) to reimagine their pedagogic priorities and classroom culture may require a new rationale for science curriculum, framed through global citizenship. If time and resources allowed, recruiting schools within another country, in which global citizenship appeared within policy aims would have provided a good international comparison, considering if this has an influence on engagement with global learning professional development.

9.4.2 Case study schools

The schools that agreed to take part as case studies included teachers who showed interest in the approach, hence self-selecting in terms of their continued commitment. Whilst being a limitation in terms of generalisability, self-selection bias provides further insight into why some schools engaged with the approach. Despite having an initial interest in global learning in primary science education,

inconsistencies and irregularities in their engagement in the were observed. Subsequently, not only does the question of sustained consistency of the global learning approach need to be addressed, igniting initial interest in sustainable development and global learning in relation to primary science must also be explored further.

9.4.3 Changing practice

Whilst not an intention of this study, as the three case study schools were only followed for two terms after the initial workshops, the research did not measure long term behaviour change, or whether the global learning approach impacted upon teacher and students' personal commitment to science and global learning. The purpose of this thesis, with a social constructivist / pragmatic paradigm, focused on how stakeholder beliefs and attitudes influence their engagement with a global learning approach to primary science and the influence of related professional development. Considering the challenges and opportunities to support practitioners as agents of change is fundamental when considering a new approach to primary science before exploring the influence on changes in practice and related beliefs about science education.

9.4.4 The attitudinal survey tool

The aim of the attitudinal survey research tool was to measure respondent attitudes towards global learning in primary science. Whilst all respondents were given a brief overview of the global learning approach, 'an approach that puts learning in a global context, fostering critical and creative thinking, self-awareness and open-mindedness towards difference, understanding of global issues and action and optimism for a better world', it must be acknowledged that all respondents and stakeholder groups will have had a different level of understandings depending on their experiences and contexts, therefore impacting on the validity of the research tool. Conducting semi-structured interviews with each stakeholder group, however, provided further insight into respondent understanding of and attitude towards global learning and primary science. Furthermore, as an emerging area of study with evolving terminology, the thesis has identified that it is these differing levels of understanding that influence engagement and subsequent integration of the global learning approach, influencing my amended theoretical framework.

9.5 Further research

9.5.1 A change in pedagogical approach in primary science

It is clear from the semi-structured interviews that trialling and experimenting with the approach and strategies within science teaching and learning are fundamental to sustained change in pedagogical approach and underpinning beliefs. Resultantly, conducting participatory action research to explore how teachers implement the approach in science and how this will impact on their understanding of

primary science will not only support the refinement of professional development, but it will enable further understanding of how and if teachers' beliefs and attitudes change.

Although it is encouraging that the case study schools revealed some pedagogical belief changes, important work remains in determining how well these belief changes translate into progressive teaching practices. Further study is needed to understand how global learning as an approach can support a culture shift in the expectation of primary science education, as well as the pedagogical approaches.

9.5.2 The impact of a global learning approach to primary science on learners

It is clear throughout this thesis that the evidence of positive impact of an approach on learning outcomes is essential for engagement, motivation and shifting pedagogy. Research focusing on the impact of the global learning approach on primary science on children's learning is both exciting and imperative for its success. Considering how the global learning approach impacts on the progression and retention of knowledge and skills, as well as the ability to apply scientific knowledge and skills to problem-solving and global issues will be an interesting area for future study. It will also be important to consider the impact on global learning experiences on children's attitude to science and their subsequent science capital, as coined by Archer et al (2015).

And finally, exploring how themes and strategies engage and empower children are important in relation to the initial research question – the extent to which the approach can raise the profile of science learning. Considering and supporting teachers and schools with relevant themes to support a global learning in primary science approach requires an understanding of successful strategies, ideas and resources.

9.5.3 Exploring ways in which professional development can support a global learning community of practice

It is clear from the wide range of suggested ways to support the global learning in primary science, that a teacher's way of developing professionally is evolving as practitioners gain more access to virtual platforms. In order to support a paradigm shift in how and what is learned in science, a shift in how professional development and ITE are delivered is also required. Supporting pre-service teachers and teachers with the tools to use and contribute to short and succinct ideas, modelled activities and professional knowledge through platforms such as Twitter, Pinterest and Instagram need to be explored. Using social media in this way may provide another level of accountability to relevant and global science, celebrating teachers as agents of change. It may also provide professionals with the confidence and impetus to bring a new lens to the curriculum they deliver. Pre-service teachers, therefore, need to be encouraged and supported to use these platforms to ensure a responsive, relevant and global primary science curriculum. Considering how this can be integrated into an ITE framework, as well as used by CPD facilitators, within professional standards, needs to be explored carefully.

Further to this, exploring the relationship between primary science education policy frameworks and related professional development in different countries will provide insight into the influence on discourse and global learning Communities of Practice. For example, comparing Scotland (Education Scotland, 2014) or Australia (Australian Curriculum, 2020), in which global dimensions are explicit in policy framework, could provide insight into the influence of macro-level support.

9.7 Final words

The global learning approach to primary science has the potential to be a vehicle to transform science learning, considering the purpose of science beyond the acquisition of skills and knowledge. Whilst the framework provides teachers, teacher educators and CPD facilitators with a blueprint for a global learning pedagogical approach in primary science education, this is insufficient. Teachers and other stakeholders must be supported to reflect on and develop their own beliefs before they can embed and facilitate a shift in pedagogical approach to primary science. Within teacher education programmes, it is suggested that science teacher educators should include opportunities for pre-service teachers to reflect on their own beliefs about science education and how to develop a curriculum (or modify a national curriculum) that is relevant to students and encourage opportunities to see science as a tool to think critically about their actions and the world around them. It is, therefore, incumbent that teacher educators support future teachers with skills of leadership and mechanisms to explore and reflect on the strategies they use to deliver a globally relevant primary science education.

A shared vision of primary science and its role in sustainable development and global citizenship will lay the foundations of the operationalisation of this approach. Moreover, at all levels, stakeholders who have a role in primary science education (from teacher educators to teachers to parents) need opportunities to develop their understanding of global issues, SDGs and related pedagogies. Practitioners require space to draw together effective pedagogical strategies, through opportunities to practice, reflect, collaborate and share their teaching of science, to create a science curriculum of coherence and purpose.

In response to the overarching research question and wider research problem, the global learning pedagogical approach to primary science education provides a new opportunity to draw together pedagogical strategies and raise engagement in the subject. This thesis demonstrated the primary science education reframed with a global context holds the possibility of reigniting the core status of the subject and its ability to support our future global citizens. As such, convincing educators to move towards a dynamic, globally relevant curricula require practitioners to be supported as agents of change, empowered to craft science teaching in ways that a relevant and meaningful to global learners, in turn, nurturing them as critical and responsible agents of change. Global learning in primary science is an example of an approach that situates science, science thinking and science teaching and learning as tools for responsible and innovative global citizens.

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APPENDICES

Appendix I An analysis of global learning initiatives

Programme, project or approach	Description	Strengths	Recommendations
Global learning as part of a spiral curriculum in geography Geography Association (2018)	A spiral approach (Bruner, 1960) to planning the curriculum, interweaving places, concepts, scales and vocabulary. Using SDGs as a focus for schools investigating global poverty and considering the merits of social justice. Critical thinking, rather than an isolated skill, aims to combines capability and context so developing understanding, and to help raise achievement.	Pupils were able to develop a greater understanding of global issues such as development, globalisation, poverty reduction, interdependence and sustainability. Schools that did the best work based it on a clear purpose for learning and on ensuring pupils had underpinning knowledge, then supported their investigation and thinking skills as a means of advancing understanding of the world.	SLT and whole school support linked to professional development targets and subject specific pedagogy – promoting a range of teaching strategies which engage and promote thinking as well as keeping subject knowledge up to date, ensuring teaching is connected with the changing world Clear understanding of global learning, linked to or explicit in the school's aims, values and ethos, or priorities for school improvement Commitment to progress, improvement and evaluation of the approach Careful planning of global learning in schemes of work and lesson plans, including clear purposes for the work; Engaging pupils in discussion about the purpose and focus of their learning through attention to knowledge and understanding of real places as the basis for the subject and global learning Development of knowledge, understanding and skills guided by the SDGs High priority for enquiry and developing critical thinking, including developing pupils' questioning, discussion and information skills Build on the leadership and contributions to global learning of subject disciplines and teachers' subject expertise in values development and critical thinking about global issues in subject teaching. Develop a better understanding of the strengths and weaknesses of different approaches to curriculum organisation, such as 'whole-school' compared with subject-based models and practices, settings, making better use of teachers' expertise and curriculum knowledge. Promote and disseminate small-scale global learning action research projects that engage and motivate teachers.
The Global Dimension in Schools (Northern Ireland) A three-year programme aiming to embed the Global Dimension in formal education. CGE (2018)	A statutory element in Primary school curricula in Northern Ireland within the themes World Around Us and Personal Development and Mutual Understanding.	Pupils were interested in global issues and were motivated to learn more about them. They were concerned about global issues and were willing to engage actively in change to make the world a better place. Teachers' confidence in tackling controversial issues improved by practice coupled with opportunities to reflect on implementation strategies, pedagogy and contents, as part of a team and individually, as well as further training focusing on the Global Dimension and its key concepts. Collaborating developed confidence and allowed teachers to develop more in-depth and complex understanding of global inequality and interdependence.	Policy documentation should provide clear guidance for teachers on how the Global Dimension should be implemented through the Curriculum: effective whole school implementation and advice on pedagogical, social and economic importance. A need to mainstream and raise awareness about the role of the Global Dimension, specifically subject-specific. ITE and In-Service Training for teachers in all subject areas should foster a critical discourse about the Global Dimension, including local and global identities achieving a more consistent approach to its implementation. Training and support should develop more critical approaches to promoting action beyond a charitable or school linking focus empowering them to address controversial issues within the Global Dimension and to link the local and the global; CPD providers should incorporate the skills, values, knowledge and understanding in their training that can enable teachers to critically engage with key social and economic issues that underpin global learning.

			ITE Institutions should continue to ensure that trainee teachers have the opportunity to introduce a global dimension to their teaching practice as part of their ITE.
Australian Sustainable Schools Initiative Lasen, Skamp and Simoncini (2017)	Sustainability is recognised as a cross-curricular priority framework – a whole school approach to embedding sustainability. Focus on inquiry-based, technology enabled praxis-oriented learning – with the intention to equip teacher graduates with the knowledge, skills, dispositions to embed EfS in curricula and whole school initiatives.	Teachers spoke of reference of EfS to students and society. The initiative resulted in more child-centred pedagogical approaches to learning.	More professional development opportunities to promote teacher content and pedagogical content knowledge and targeted resources for EfS implementation. Teacher notions of sustainability is limited to the environment, therefore more training around other areas of sustainability is needed. More focus on critical thinking skills and critically reflective knowledge.
Global Learning Programme – Scotland Global Citizenship Monitor (2015)	In Scotland, the programmes aim to demonstrate links to broader educational strategies that incorporate sustainable development.	Teachers report beginning to recognise that education for global citizenship is an on-going process and that they don't have to know everything at once. Greater realisation that teachers learning and exploring alongside their pupils without losing 'authority'. Embedded global citizenship is less difficult than teachers thought, realising that is not 'another thing to add in' but is already present. Evidence (Education Scotland, 2014) indicates importance of learning for sustainability in increasing learner motivation, engagement, participation and skills for learning, life and work.	Pedagogies need to ensure learners develop the ability to think critically and creatively and to analyse, evaluate and synthesise complex issues and apply their learning in new contexts. Pedagogies should also encourage a systems' thinking approach (Education Scotland, n.d.).
ACTION CANADA (O'Brien and Howard, 2016)	This initiative represents a shift in emphasis from the instruction of facts to a model which focuses on competencies such as critical thinking, character, creativity, innovation, as well as digital and computer literacy.	While technology is not the end in itself, it has shown to be a key enabler of 21st century learning; Evidence shows a significant and positive association between teacher education and the facilitation of 21st century learning in the classroom	Need for greater coordination around 21st century learning to ensure there is an opportunity for knowledge sharing and of resources. Emphasis on teacher education and professional development for the facilitation of 21st century learning in the classroom.
Global Learning Programme Wales (Bourn et al, 2016)	Education for Sustainable Development and Global Citizenship (ESDGC) is a cross-curricular theme, and its stated is to 'give learners, at all stages of education, an understanding of the impact of their choices on other people, the economy and the environment' (Welsh Government, 2014). Specific themes, include the natural environment, consumption and waste, climate change, identity and culture, wealth and poverty,	The ESDGC curriculum in Wales demonstrated positive impact on children's understanding of concepts of sustainable development and global citizenship (ESTYN, 2014). Participation in school committees e.g. eco-committee, school council has increased as a result of ESDGC (Keep Britain Tidy, 2013; ESTYN, 2014).	More professional development and a designated teacher in each school to lead ESDGC (Estyn, 2014) Further research on effective pedagogy for global and environmental social justice and on the impact on children's learning and development. Clear vision for ESDGC with policies which clearly defined ESDGC and what it means for staff, pupils and the wider community. Effective planning through subjects should be more systematic rather than through uncoordinated projects. Continued CPD and training is important to build teacher confidence.

	choices and decisions and health.		
Global Learning Project England (Bourn et al, 2016)	Global Learning Programme in England in collaboration with NGOs, subject associations and the have all encouraged schools to use themes such as respect, tolerance and social justice to promote links between the British values policy (DfE, 2015) and broader conceptualisations of global learning (Bowden, 2015). GLP-England uses a hub and spoke model of engagement, in which lead schools run a network of local schools to support teacher development.	Impact evidence includes stronger levels of confidence, knowledge and skills to introduce global learning into teaching, and in turn improve global learning outcomes for children.	Emphasis should be on the school as a whole rather than on individual champions to ensure sustained engagement. Continued involvement of the school requires SLT support and ongoing professional development for all staff. Needs to be emphasised as integral to the curriculum rather than an add-on (Hunt, 2012).
Using global data in primary mathematics, (Pendry, 2018)	Modelling global strategies in maths lessons	Global data in mathematics improves engagement from both teachers and pupils. Evidence of increased engagement in maths lessons as pupils were interested in the global data that was being used to contextualise maths learning. Evidence of enthusiasm and engagement in maths lessons that used real data. Evidence of less able and/or less engaged pupils were more inclined to join in lessons and activities that used global data, making greater progress and showed a greater keenness to participate in other similar lessons. Use of global data in mathematics is an important strategy for making maths 'real and relevant', motivating engagement.	Importance of helping children reach a depth of understanding in both subject and global learning, allowing them to transfer their learning to other / new concepts helping them to see the relevance of their learning; A need to equip teachers with the skills to harness global issues and turn them into valuable and effective subject activities; Demonstration and coaching lessons support teacher confidence; Production of online supporting material further develops global learning in a subject area.
Global Learning Writing Research Project (Alcock and Barker, 2016)	Uses Development Education (DE) methodologies (dialogue-based and participatory learning to help children become aware of different perspectives, e.g. Diamond Nines, Philosophy for Children (the global citizenship version), role play, problem solving, simulation games, paired discussion techniques, and multimodal literacy opportunities (such as online global learning resources).	Increased opportunities for talking, discussion, debating and exploratory talk leading to pupil progress within writing, e.g. adding detail and description and through well documented pupil progress data; Evidence of enthusiasm for global learning and DE methodologies bringing refreshed motivation for writing, as evidenced in pupil feedback and teacher observations of pupils' progress. Global learning and DE methodologies have opportunities to develop meta-cognition skills. Increased dynamics of teacher learning correlates with pupil learning.	Senior leadership and a clear vision are important when ensuring progress with this type of intervention, where global learning falls outside of the current conceived agenda for raising standards.

Appendix II SDGs mapped against the National Curriculum Primary Science Programmes of Study

Sustainable Development Goals and associated targets	The National Curriculum Primary Science Programmes of study (DfE, 2013)	Rationale
SDG1: No Poverty		**How can we make sure we all have the things we need to live comfortably?**
1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	Animals including humans (understanding the need for an adequate, balanced diet) Understanding what constitutes a balanced diet including protein, carbohydrates, fats and oils, water, minerals (limited to calcium and iron) and vitamins (limited to A, C and D), and describe the functions of these nutrients.	Whilst science objectives focus on the balance of nutrition, links between science and maths could be used to identify what a balanced diet costs. This allows us to appreciate how little $1.25 is.
1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Properties and uses of materials Rocks and soils (Yr 3)	Understanding the uses and properties of different materials on our Earth, as well as how they are unevenly distributed (including rocks, minerals, fossil fuels, nutrient-rich soil and even water) is the basis of understanding poverty and inequality. Appreciating the properties of rocks types and their uses is important to understand their desirability.
1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.	Aims of science curriculum: Uses and implications of science knowledge today and in the future.	An understanding of how the quality of soil impacts on plant growth will help children appreciate the impact of both flooding and desertification on food production, considering solutions for this. Supporting communities with stable infrastructure resistant to disasters such as earthquakes and flooding will require an understanding of properties of materials as well as their structure and design. An understanding of plate tectonics and areas which are more susceptible to Earthquakes and volcanoes will allow individuals to appreciate how local communities can prepare, predict and reduce vulnerability through appropriate infrastructure and innovation.
SDG2: Zero Hunger		**What can be done to ensure that every child has sufficient and nutritious food in order to grow up healthy?**
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.	(CROPS) Plants (Yr 1 – 5) (Animals and their habitats) Understanding features of animals and their habitats, as well as food chains and webs (FOOD HYGIENE) Animals including humans	Understanding how food is produced, processed and accessed (through farming and fishing) is fundamental to its sustainable access. Considering alternative food supply such as seasonal crops and eating insects may support local communities to become self-sustainable. Sharing knowledge is underpinned by an understanding of different food groups and how they can be produced and processed. Developing an understanding of food hygiene and food preservation is underpinned by knowing how micro-organisms can cause food decay and how this can be prevented.
2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of	Animals including humans (Diets, health and hygiene)	A basic understanding of the life process of nutrition, including how we digest the food we eat and how we can maintain a balanced, varied diet, is fundamental to this target.

adolescent girls, pregnant and lactating women and older persons		
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.	Plants (growth and life cycles) Animals and their habitats (energy transfer and food chains)	Developing an understanding of sustainable food production, prevention of diseases in plants and animals, and avoiding over-fishing / farming through basic knowledge of food chains.
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.	**Animals and their habitats** **Rocks and soils** **Plants**	A knowledge of how food is produced and cultivated, as well as the impact of flooding, desertification, extreme weather and over farming. An appreciation of the fragile balance in an ecosystem and how climate change / weather / natural disasters can have a domino effect on organisms within it. Understanding the role of decomposers in the recycling of nutrients is important to understand how soil quality can be preserved and enhanced.
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.	Variation (Plants and animal diversity)	A basic understanding of a plant's life cycle and seed production is important for this goal. A developing understanding of biodiversity through genetics is also important for this target.
SDG3: Good Health and Well-Being	**Animals including humans**	**What do children and young people need to stay healthy?** A celebration of jobs that enable us to prevent and treat illnesses and diseases (from health professionals to immunologists to care workers) as well as those which enable us to maintain good health (e.g. fitness instructors, etc). An appreciation of how a knowledge and understanding of the world can help us make responsible choices about our impact on our own health and that of others. Whilst dental hygiene and fitness do not fall into any SDG 3 specific target, an awareness of these are important for physical health and wellbeing.
3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births	Year 6 Animals including humans (health)	An appreciation of human reproduction and maternal health is essential for the achievement of this goal.
3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births	Animals including humans (diet, health and hygiene)	Malnutrition is a large cause of death for children under 5 years old. Understanding the importance of diet and hygiene is important to support the survival of this age range.
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.	Animal classification Micro-organisms Health and hygiene	An appreciation of the importance of this target is underpinned by an understanding of micro-organisms as living things. It is essential to develop a growing understanding of how they survive and travel, as well as their impact on humans and other organisms. A basic understanding of how diseases spread and how we can take preventative measures through good personal hygiene, food hygiene and awareness will allow learners to contribute to this goal.

3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being	Animals including humans (health and hygiene)	An understanding of how medicines can be used to treat illnesses and how to ensure safe use. An understanding of causes, symptoms and treatments for different illnesses. An awareness of lifestyle choices and their effect on the human body is essential for the prevention of premature mortality.
3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.	Year 6 Animals including humans	An awareness of lifestyle choices and the effect of drugs and alcohol on the human body is essential for prevention.
3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.	Lifecycles (Yr 5) Health and hygiene	A foundational understanding of reproduction as a life process must come before appropriate sexual and reproductive health education, see 0097, pg12.
3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.	Animals including humans (health and hygiene)	An understanding of access to medicines and vaccinations is important to prevent and treat diseases and illnesses.
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.	Understanding the impact of humans on the environment Materials and changes	Developing an understanding of how diseases and illnesses can be transmitted through the respiratory and digestive systems. Developing an understanding of how human activity can affect the quality of air, water and soil, which can have a knock-on effect on all living things. Knowing the hazards symbols of chemicals will reduce death and illness
SDG4: Quality Education		**What else is needed for every child and young person to have a good education?** Providing a high-quality science curriculum will allow children to appreciate the importance of life-long learning, understanding that allows for science literacy and knowledge and skills for future careers (both within and beyond science-related careers).
4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	The science curriculum aims to provide knowledge, understanding and skills, as well as uses and implications of science for now and the future. Working Scientifically skills provide importance transdisciplinary skills.	Transdisciplinary skills will enable young people to problem-solve and thrive as they make future career choices. Scientific skills enable young people to use science within a range of contexts, for example, making observations, predictions from models and representations, collecting evidence, analysing data, evaluating accuracy and understanding the use of data. All of these are desirable skills in a range of careers.
4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	Working scientifically	The science curriculum, through nurturing global learning attributes, the science curriculum will enable young people to make responsible choices to ensure global sustainability and innovation.
SDG5: Gender Equality		**Why is it important for girls and boys to be able to do the same things?** Through supporting a 'science capital approach', young people can see the importance of science for themselves and their future, regardless of gender and economic background.
SDG6: Clean Water and Sanitation	States of matter Materials	**What are the most important things you use water for? What if you did not have it? How can we make sure that we all have access to safe water?**

(Science underpins basic water literacy, responsible consumption and management).		Through activities where children are collecting and measuring water and considering how much water they are using for daily The simple understanding of water and its behaviour enables an appreciation of vital for the achievement of this goal. Through activities such as cleaning teeth or going to the toilet, learners will be developing skills of using measuring equipment, recording measurements whilst gaining an appreciation of water as an important resource. Understanding the water cycle through a model provides an awareness of how modelling can promote an understanding of water as a universal commodity.
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Animals including humans States of matter	Learners must appreciate the importance of water for survival. They must also understand much of the planets water is either inaccessible or unsafe to drink directly.
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	Animals including humans	Learners must understand the importance of good water access to maintain hygiene and prevent the spread of disease.
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	States of matter Animals including hum,ans	Having a foundation understanding of the implications of industry on the environment, specifically in terms of water pollution. Begin to understand the process of separating water from both soluble and insoluble substances through filtering, evaporating and distillation. As individuals move into secondary, a deeper understanding of water at a particular level will help them understand how it can be contaminated / cleaned.
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	States of matter – the water cycle	Understanding water as a limited resource, how it can be conserved and recycled will enable a community to use it more responsibly.
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	States of matter	Whilst 71% of the Earth's surface is covered in water, only 0.6% is drinkable. Having a foundational knowledge of the water cycle and how it doesn't respect political boundaries provides an important foundational understanding to using it responsibly.
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	Animals and their habitats	An understanding of water-based ecosystems and habitats will allow learners to appreciate the human impact on ecosystems, food chains and industry (such as fisheries).
SDG7: Affordable and Clean Energy	**Uses and implications of science**	**What are the things you use at home or in school that require electricity? Why is it important that all children and young people have it?** An overarching critical awareness of how energy is generated locally and globally, as well as the impacts on the environment, are important for the achievement of this goal.
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	Electricity	It is important that learners appreciate how electricity is used and needed for most things in daily life. It is also important to understand how electricity works in order to power devices safely and efficiently.
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	Electricity and forces	A developing understanding of how energy is created and converted from one form to another is required to support and develop renewable energy generation.
7.3 By 2030, double the global rate of improvement in energy efficiency	Electricity	Understand what uses electricity allows us to consider how we can reduce its use and use it more efficiently.
SDG8: Decent Work and Economic Growth	Working scientifically skills	**Why is it important that people can find good jobs? What might make it easier for everyone to find a good job?**

		Children with the skills of confidence, reflection, innovation, creative and critical thinking will underpin the achievement of this target. Thinking and working scientifically supports the development of a range of transdisciplinary skills which can support economic productivity.
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead	Understanding the impact of humans on the environment	Sustainable resource consumption and production is underpinned by an understanding and appreciation of where resources come from, how they are manufactured and exploring alternatives in relation to their properties.
8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	An understanding of science and the impact of humans on environments	Providing young people with the knowledge and skills to make informed choices, considering sustainability will support them to promote sustainable tourism. An awareness of the impact of humans on the environment is required to inform sustainable tourism policies.
SDG9: Industry, Innovation and Infrastructure	Working scientifically	**Do you believe schools can do more for the environment?** Science learning supports young people to use scientific knowledge and skills to solve problems, research ideas and create inventions.
9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	Relationship between materials, forces and infrastructure	A basic understanding of the properties and uses of materials, and how they can be used responsibly can inform the development of infrastructure such as roads, buildings, water supply and electricity supply.
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	Materials and their properties Forces and movement Rocks and soil Earth and space	Sources and properties of materials underpin considerations of how they can be used more efficiently as infrastructure is developed and improved. Building and infrastructure development also requires a foundational knowledge of forces and energy sources. Developing innovative transport and technology requires an understanding of science concepts related to forces and motion.
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	Working scientifically	This target is underpinned by an understanding of how science research can inform innovation and development.
SDG10: Reduced Inequalities	**Aims of science**	**Do you believe schools can do more for the environment?** Ensuring young people, regardless of age, sex, disability, race, ethnicity, origin, religion and economic status, are empowered by their scientific understanding of the world, are able to use science to inform life choices and access opportunities.
10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status	An understanding of variation and diversity through life cycles, and being able to celebrate similarities and differences.	This target requires an understanding and celebration of variation and difference.
SDG11: Sustainable Cities and Communities	Uses and implications of science knowledge	**What are the things that would make cities cleaner and better for children and young people?** Developing sustainable cities and communities will require learners to be responsible, innovative and

		engaged, making informed choices to support the development sustainable cities and communities.
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	Materials and their properties States of matter Forces	Foundational knowledge of materials and their properties, energy production and usage, forces and structures, combined with the attributes of responsibility, engagement and innovation will lead to innovative housing and basic service development.
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	Forces and movement	Transport innovation and sustainability requires knowledge of forces and movement which develops through the stages of the science framework.
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Uses and implications of science	Developing sustainable cities and communities will require individuals to be responsible, innovative and engaged, making informed choices to support the development sustainable cities and communities.
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Animals and their habitats	The more young people know and learn about nature in local environments, the better equipped they will be to protect and safeguard it.
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	Earth and space	Foundational knowledge about the causes of natural disasters can support informed decision-making to reduce the impact of them on people, e.g. through the development of technology and building design.
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	Materials and their properties Earth and space States of matter.	Knowledge of gases and air in particular will inform an understanding of how this composition can be changed by human activity and its subsequent prevention. Through an understanding of respiration, an appreciation of poor-quality air on humans, can also be gained.
SDG12: Responsible Consumption and Production	Materials and their properties and changes States of matter Uses and implications (aims)	**What are the small things you could do in your daily life that would help waste fewer resources like water, food, trees and energy?** Foundational knowledge of materials and their properties, and energy production, combined with the attributes of responsibility, engagement and innovation will lead to responsible consumption and production.
12.1 Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	States of matter Materials and their properties	Foundational knowledge of materials and their properties, and energy production, combined with the attributes of responsibility, engagement and innovation will lead to responsible consumption and production.
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Properties and uses of materials	A knowledge of sourcing and properties is required to make responsible decisions of material uses.
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	Food chains Materials	Responsible consumption and reduction of food waste requires an appreciation of the energy, land, water, fertilizers and other inputs needed to grow and distribute that food.
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	Soils and rocks Materials Animals including humans Animals and their habitats	Management of chemicals and waste requires a knowledge of the composition of air, soil and water, as well as the importance of these aspects of the environment of plant growth, food chains and human health.

12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	Properties and uses of materials	Foundational knowledge of materials and their properties and the energy required to manufacture raw materials, combined with the attributes of responsibility, engagement and innovation will lead to responsible consumption and production.
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	Properties and uses of materials.	The attribute of responsibility combined with a knowledge of the impacts of humans on the environment. For example, considering the impact of diet on the environment. Other aspects of lifestyles such as transport, pastimes and energy usage all require an awareness of their impact on the environment.
SDG13: Climate Action	Earth and space States of matter Animals and their habitats	**Why is a changing climate important to children and young people? What are some the impacts that you might face?** In order to support the goal and targets related to climate action, the science knowledge underpinning causes and effects of climate change must be constructed. This includes knowledge related to states of matter, changes of state, gases, energy transfer, chemical changes, climate and the carbon cycle.
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Earth and space States of matter Animals and their habitats	A knowledge of the causes and effects of both climate-related hazards and natural disasters will enable individuals to contribute to ways in which we can respond to them.
13.2 Integrate climate change measures into national policies, strategies and planning		Informed policy, strategies and planning require an understanding of what causes climate change and ways in which human impact can be minimised.
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Uses and implications of science knowledge	Aside from development of knowledge underpinning a better understanding of climate change itself, supporting children to talk about the value of science in the positive and negative environmental effects of human activity is essential in the achievement of climate change mitigation, adaptation and impact reduction. [
SDG14: Life Below Water	Animals including habitats	**What are some of the important things we use and find in the ocean? Why is it important they are protected?** Protecting life below water requires a progressive understanding of underwater habitats, animal survival and adaptation, as well related food webs and food chains. This knowledge will enable individuals to consider the impact of changes.
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution		
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans		
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels		Along with an appreciation of how animals are adapted to specific conditions, and the impact of changes to these, to contribute to minimising and addressing the impact of ocean acidification, individuals need to know: - How substances are dissolved in water; - How climate change and increased amounts of CO2 cause acidification to water (through chemical change); - How increasing the number of plants in the water can help use up some of the CO2.
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics		Knowledge of how the reduction of fish can have an impact on all organisms within a ecosystem requires an understanding of food chains and food webs.

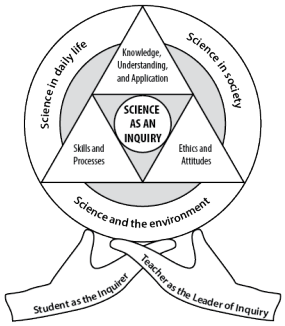
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information		Along with an understanding of animals in their habitats, it is important to appreciate of how scientific information can inform conservation.
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation		Understanding the delicate balance of organisms within an ecosystem is required to understand the knock on effect of overfishing on related food chains within it.
SDG15: Life on Land	Animals and their habitats	**Is it important to have a diversity of plants and animals around the world? What can children do to help protect species and their habitats?** In order to respect and protect all life on land, a progressive understanding of animal interdependence, survival and diversity is essential.
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements		Conservation, restoration and sustainable use of ecosystems requires as understanding of human impact on them.
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally		A developing understanding of forest ecosystems and the importance of trees will inform this goal.
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world		A basic knowledge of soil science underpins an understanding of how land and soil quality can be preserved.
15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development		As above, a developing understanding of mountain ecosystems and the importance of biodiversity
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species		An understanding of the fragility of balance within ecosystems will inform national and local planning with an awareness and responsibility to protect biodiversity.
15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed		In order to conserve and use genetic resources for food security for present and future generations, we need to ensure equal and fair access to traditional knowledge, innovations and practices relevant to the conservation of plant genetic resources. This requires a foundational knowledge of genetics and evolution.
15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products		Knowledge of the balance in an ecosystem and how changing it can have a knock-on effect on all organisms within it.
15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species		Knowledge of the balance in an ecosystem and how changing it can have a knock-on effect on all organisms within it.

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts		An understanding of the fragility of balance within ecosystems will inform national and local planning with an awareness and responsibility to protect biodiversity.
SDG16: Peace, Justice and Strong Institutions	Working scientifically	Supporting children to work collaboratively, respect the work and views of others is the basis of this goal. Science learning enables children to develop the core attributes to support peace, justice and strong institutions.
16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels	Working scientifically	Science learning provides an opportunity to develop transdisciplinary skills in working collaboratively and inclusively to solve problems and make decisions.
SDG17: Partnerships	Collaborative work when working scientifically	Whilst the targets related to this goal are not science-specific, a science teacher guide supports and encourages partnership and collaboration to conduct enquiries, solve problems and consider different perspectives. These skills are essential for the achievement of this goal.

Appendix III: The attitudinal survey for Global learning in primary science

Weighting	Statement
6.31	I think it's really important for young people to know what's going on in the world
1.00	Having a global dimension to my science lessons is totally pointless and would detract from important learning
6.85	Global learning is absolutely essential for the development of myself and those that I teach
2.00	Global learning is a low priority issue on the scale of what is important in my life and my work
3.08	Whilst creative thinking is important there are things in science which take a higher priority
5.69	Global learning adds to pupil learning of science
4.00	I think global learning is significant but honestly don't know if it is more or less important than mathematics or English
5.38	Young people should be aware of different perspectives in science
2.08	Global learning is too complex to engage with
2.46	Incorporating global learning in science is beyond the role/scope of being a teacher
1.00	I hate the whole idea of teaching about global learning in science
4.23	Whilst global perspectives in learning could be important, the concept may need further clarification to be usefully applied to the science curriculum
6.85	I am very passionate about global learning
5.15	Global learning is possibly one way to promote critical thinking in science lessons

Appendix IV: Science Curriculum aims around the world

Country	Curriculum aims (From Timms and Pirls, 2015)
Singapore	 Science syllabi are designed around themes that students can relate to in their everyday experiences and on commonly observed phenomena in nature. The five themes at the primary level are diversity, cycles, energy, interactions, and systems.
Republic of Korea	Students are expected to develop scientific literacy that will allow them to solve problems creatively and scientifically in daily life. Specifically, the science curriculum aims to accomplish the following: • Help students understand basic science concepts through activities involving inquiry • Motivate students to develop interest in and curiosity about natural phenomena and objects • Facilitate student development of scientific thinking skills and creative problem-solving abilities.
Japan	Objectives help students do the following: • Develop perspectives and ideas about the properties and functions of objects by investigating air, water, changes in states of matter, and electrical phenomena in relation to the functions of power, heat, and electricity, and by exploring identified problems and making learning materials with interest • Develop a loving and protective attitude toward living things; and develop perspectives on and ideas about the structure of the human body, the activities of animals, the growth of plants, meteorology, and the movement of the moon and stars by investigating them in relation to movement, the seasons, temperature, and time and by exploring identified problems with interest
Russian Federation (2009)	Objectives of mastering content knowledge and skills, meta-subject skills, and personal characteristics. These objectives are reflected in the new science curriculum, which requires teachers to take into account all three aspects of student competency when organizing the learning process. Students will have laid a foundation of environmental and cultural literacy and will be able to observe best practices in nature and society, ensuring a healthy lifestyle and sustainable conduct toward the environment.
Hong Kong SAR	Curriculum guide states that the goals for students in science education are: • Develop curiosity and interest in science • Develop the ability to inquire and solve problems • Acquire basic scientific knowledge and concepts for living in and contributing to a scientific and technological world • Recognize the usefulness and limitations of science and the interconnections among science, technology, and society, and develop an attitude of responsible citizenship, including respect for the environment and commitment to the wise use of resources • Become familiar with the language of science and be equipped with the skills to communicate ideas in science-related contexts • Appreciate and understand the evolutionary nature of scientific knowledge • Attain personal growth through studying science • Be prepared for further studies or careers in scientific and technological fields
Chinese Taipei	The goal of the science curriculum is to increase science literacy. Science literacy encompasses eight domains: Knowledge of Science and Technology, Science Processing Skills, Development of Processing Intelligence, Scientific Applications, Designing and Producing, Understanding the Nature of Science, Understanding the Development of Science and Technology, and Development of Scientific Attitudes.
Finland	Environmental and Natural Studies is taught as an integrated subject encompassing the fields of biology, geography, physics, chemistry, and health education. Instruction focuses on sustainable development allowing students to know and understand nature and the manmade environment, themselves and other people, human diversity, and health and disease. Instruction in environmental and natural studies relies on an investigative, problem-cantered approach in which the starting points include students' existing knowledge, skills, and experiences, and things, phenomena, and events connected to their environment and the students. With the aid of experiential instruction, the students develop a positive relationship with nature and the environment.
Kazakhstan	Science in Grades 1 to 4 is taught through the integrated course Knowledge of the World, which includes the following components: • Nature—Living and nonliving things and their attributes; natural phenomena and their properties, conditions, and interrelationships; and the animal and plant world, including common features, basic needs, reproduction, and habitats

	• Humans—The concept of humans as a part of the natural world; significant features that differentiate humans from animals; and man's role in the development of science, technology, the environment, and society • Society—The homeland, family, school, and understanding oneself and one's position in society
Poland	Five teaching objectives for this subject: • Arousing curiosity about nature • Respect for nature • Constructing and verifying hypotheses of natural phenomena and processes • Observation, measurement, and experimentation • Practical use of knowledge about nature
United States of America (2013)	K to 12 science standards, called the Next Generation Science Standards (NGSS), has three dimensions that are integrated into instruction at all levels: (1) disciplinary core ideas in the natural sciences (life, physical, and Earth and space sciences), as well as in engineering, technology, and applications of science, which reflect the content to be learned across subject areas; (2) scientific and engineering practices, such as investigating, using models, interpreting data, constructing explanations, and designing solutions, which elaborate the processes and habits of mind in science and engineering that students should develop and apply; and (3) crosscutting concepts, such as energy, matter, and systems, which reflect key underlying concepts that apply across the domains of science and unify the study of science and engineering.
Slovenia (2011)	Natural sciences are taught within the subject of environmental education, designed to show the great complexity, diversity, and interconnectedness of factors active in humans' natural and social environments. Learning about the environment combines processes, procedures, and topics used by students to learn about the world they live in. The subject comprises natural and technical topics (chemistry, physics, biology, informatics, technical science, and technology), as well as social sciences (history, geography, communication science, sociology, economy, and political sciences). By third grade, students should have learned about the following: themselves and the environment in which they live; their own social history; their connection to nature; the importance of health; how to define the features of materials and objects; and the physical principles of movement and force, Earth and the universe, space and time, weather, and sound.
Hungary	Investigate, understand, and describe ideas about commonly experienced natural phenomena and simple relationships among them; identify materials and organisms by action and experience; observe, compare, and classify non-living and living things; communicate and interpret personal experiences of scientific phenomena; carry out simple experiments and track the processes under investigation; become acquainted with sources of information and their uses
Sweden (2011)	Science instruction should meet the following aims: • In biology: Use their knowledge of biology to examine information, communicate, and form an opinion on questions concerning health, the use of natural resources, and ecological sustainability; Use concepts of biology, its models, and its theories to describe and explain biological relationships in the human body, nature, and society • In chemistry: Use their knowledge of chemistry to examine information, communicate, and form an opinion on questions concerning energy, the environment, health, and society; Use concepts of chemistry, its models, and its theories to describe and explain chemistry in society, in nature, and in people • In physics: Use their knowledge of physics to examine information, communicate, and form an opinion on questions concerning energy, technology, the environment, and society; Use concepts of physics, its models, and its theories to describe and explain physics in nature and society
Norway	Knowledge and understanding of the natural sciences constitute a basis for participation in the democratic process and enable people to contribute to sustainable development. Learning science must be closely related to practical experience in laboratories and nature. "Natural science is the result of human curiosity and our need to find answers to questions about our existence, life and life forms, and our place in nature and the universe, and, in this way, it becomes part of our culture." The curriculum emphasizes the holistic nature of the subject even though natural science is divided into the disciplines of physics, chemistry, biology, and the geosciences. The curriculum also states that scientific laws and theories are models of a complex reality, and that these models are developed through observations, experiments, and ideas. In short, the science curriculum emphasizes the importance of understanding both the content and the nature of science.
England (2013)	The national curriculum for science aims to ensure that all students: • Develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry, and physics • Develop understanding of the nature, processes, and methods of science through different types of science inquiry that help them to answer scientific questions about the world around them • Are equipped with the scientific knowledge required to understand the uses and implications of science, today and for the future

Appendix V How the aims of primary science align aims of a global learning approach

Science Programme of study aims:

- Develop scientific **knowledge** and conceptual understanding through the specific disciplines of biology, chemistry, and physics;
- Develop understanding of the nature, processes, and methods of science through different types of **science inquiry** that help them **to answer scientific questions about the world around them**;
- Are equipped with the scientific knowledge required to understand the **uses and implications of science**, today and for the future.

What is global learning?

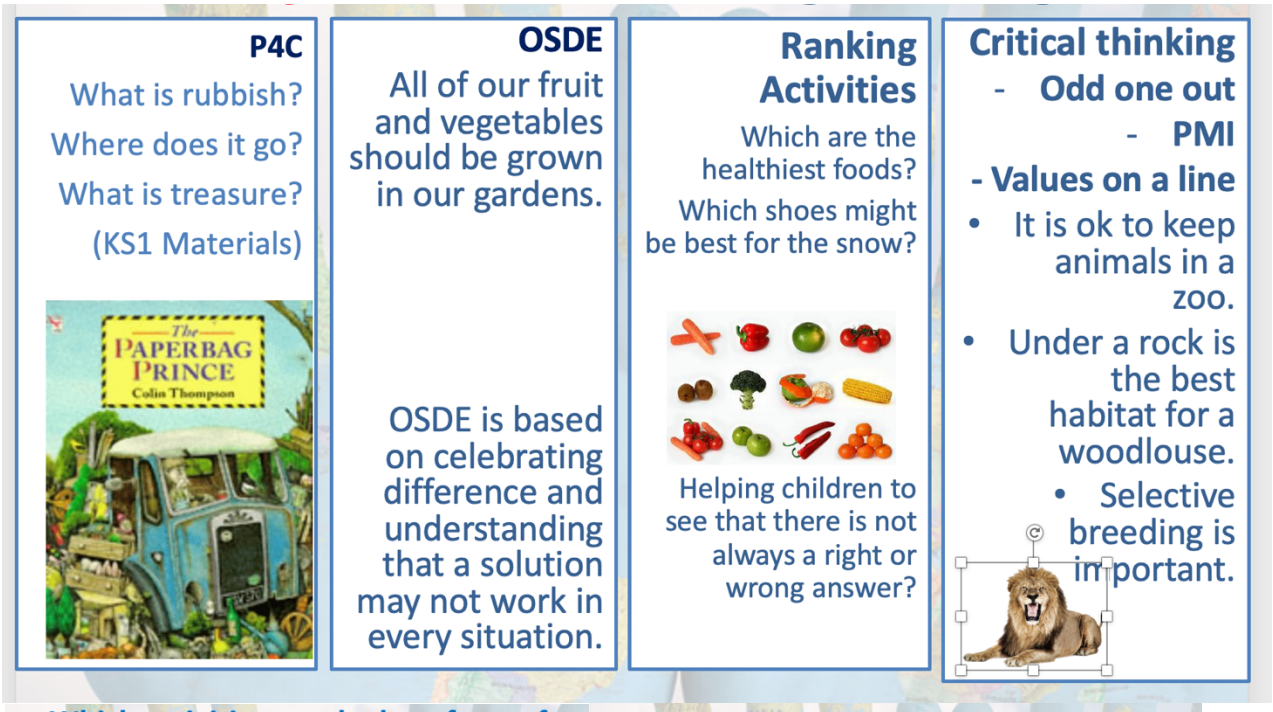
A pedagogical approach which helps children:

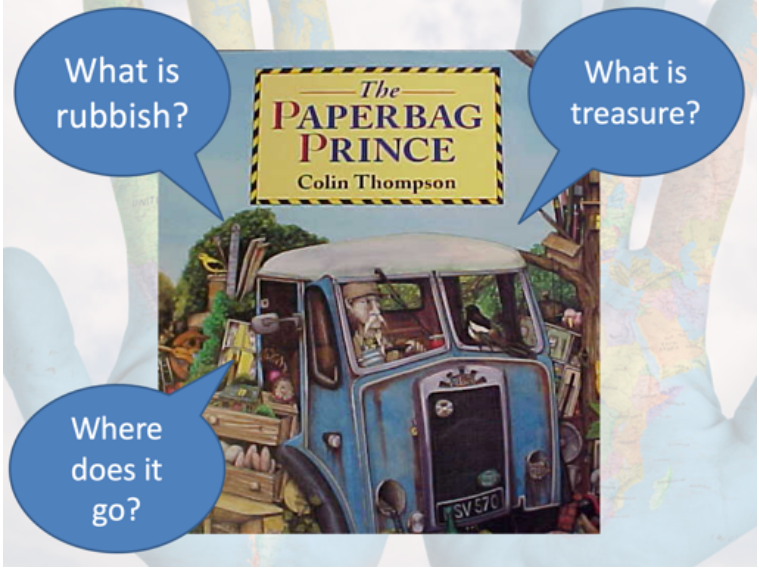
- Explore and make sense of the **big issues** in the world;
- **Think critically** and creatively about topical and controversial issues;
- Be **active participants** in their own learning (developing skills of problem-solving and enquiry);
- Look at issues and events from **different perspectives**;
- **Communicate** with and learn meaningfully about people from a range of cultures and countries;
- Develop **self-awareness** and positive attitudes about difference;
- Argue a **position** or view;
- Reflect on the **consequences of their own actions** now and in the future;
- Link learning to take **responsible action**;
- Participate in society as active and **responsible global citizens**.

What is global learning in primary science?

- Explore and make sense of the **big science issues**;
- **Think critically** and creatively about topical science;
- Be **active participants** in science enquiry;
- Consider **different perspectives to scientific ideas**;
- **Communicate** with and learn meaningfully about scientists from a range of cultures and countries;
- Develop **an awareness of different approaches to scientific enquiry (what type of scientist are you?)**;
- Argue a **position** or view;
- Reflect on the **consequences of their own actions** now and in the future;
- Link science learning to take **responsible action**.

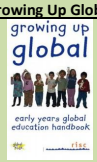
Appendix VI A carousel of global learning pedagogical strategies





Appendix VII Global learning resource handout

Global Learning in Primary Science Resources

First News  **1 in 4 copies have science on the front cover. www.firstnews.co.uk**	Topical Science Updates  **topicalscienceupdates@gmail.com**	Reach Out Reporters  **www.reachoutreporter.com**	Polar Explorers **www.stem.org.uk/polar-explorer-educational-resources**
Practical Action STEM challenges  **A range of different STEM challenges that can be both incorporated into lessons or used for transition, curriculum enrichment day, parental engagement or a STEM club. https://practicalaction.org/stem**	**Wellcome Trust Crunch**  The Crunch includes exciting free activities and resources about how our food, our health and our planet are all interconnected. **https://thecrunch.wellcome.ac.uk/**	**Fair trade resources** Learning through Fairtrade opens up a fascinating world, revealing how we are all connected. Use our curriculum resources to discover where our food comes from. **https://schools.fairtrade.org.uk/**	**Growing Up Global**  An Early Years handbook that demonstrates how global education can be a thread running through learning and teaching.. http://w3.risc.org.uk/education/resources
Oxfam Global Learning STEM resources  **https://www.oxfam.org.uk/education/**	**Oi Get Off Our Train – J. Burningham**  An ideal story to introduce the need to look after the environment, and could be followed up by research about the animals and habitats mentioned in the story.	**Digital Explorer** Digital Explorer engages young people in global issues for a better future. Our unique projects provide inspirational lessons and resources direct from the world to your classroom. **http://digitalexplorer.com/**	**Global Primary Science**  Suggested ideas and links related to the science curriculum. **https://globalprimarysciencecouk.wordpress.com/**

Appendix VII A global learning in primary science planning framework

Programme of Study – Global Learning in Primary Science Planning framework			
Year Group:		Programme of Study:	
Wider Purpose / Global context / SDG lens:		**Global Competencies / attitudes developed:**	
Pedagogical strategies (P4C, critical thinking, OSED, etc):		**Meaningful scientific enquiries (Progression of working scientifically skills):**	
Child-led enquiries and application of learning:			
Global Competencies: Understanding different perspectives, collective responsibilities, collaboration and communication, awareness of global issues, problem-solving.			

Appendix VIII A global learning approach to primary science education (key pedagogical strategies)

Strategies aligned with critical and creative thinking, self-awareness and open-mindedness towards difference, understanding of global issues and power relationships and optimism and action for a better world.

Pedagogical approach / mindset / methodology	Principles	Alignment with global learning approach	Alignment with primary science learning	Global learning approach to primary science
Open Spaces for dialogue and enquiry (OSDE) Creation of open spaces in which children are invited to engage critically, through dialogue, with their own as well as others' perspectives, Andreotti and Warwick (2007). Central to the OSDE initiative is the focus on engaging learners in controversial issues with a global dimension.	- That every individual brings to the space valid and legitimate knowledge constructed in their own contexts. - That all knowledge is partial and incomplete. - That all knowledge can be questioned. OSDE aims to promote change without imposing views or actions, by creating spaces where they are safe to analyse and experiment with other forms of seeing/thinking and being/relating to one another (Andreotti and Warwick, 2007:6).	Approach supports critical thinking, openness and commitment to understanding different perspectives, enabling critical citizens who can deal with the complexities, changes and uncertainties of the diverse and unequal society in which they live.	Using OSDE enables children to engage critically, through dialogue, with their own as well as others' perspectives when considering approaches to scientific enquiry and application of scientific evidence.	***We should only eat the fruit and vegetables we grow in our garden.*** ***Informed thinking*** Using scientific enquiry to explore how to grow different fruits and vegetables, find out why it is important to eat fruit and vegetables and investigate how long fruit and vegetables last. ***Reflective questions*** Which fruits and vegetables do you like? Why might you not grow fruit and vegetables at home? Where do your fruit and vegetables come from? Do they come in packaging? Do they come from a different country? ***Group dialogue questions*** Do other people think and do the same? Or something different? ***Responsible choices*** What do you think now? What fruits and vegetables will you eat? Where will they come from? **Debriefing** What did you learn? Do you think anything different from before?
Philosophy for Children (P4C) A teaching methodology that helps develop pupils' critical thinking and enables them to engage with complex and controversial global issues. 'P4C aims to help children become more thoughtful, more reflective, considerate and reasonable individuals,' Lipman, 1980.	Four modes of thought (critical, creative, caring and collaborative) **Critical thinking** (questioning and reasoning) **Creative thinking (**connecting and suggesting) **Caring thinking** (appreciating, empathising and valuing emotions) C**ollaborative thinking** (responding and supporting)	P4C uses a dialogical approach to learning, looking at issues from different viewpoints and encouraging critical thinking.	P4C enables children participate in dialogue concerning the content of science (science concepts), the nature of science and the consequences of science (social, ethical and technological), (Dunlop, 2015).	***What if we all had to walk to school?*** ***Critical thinking:*** How does exercise affect our bodies? How can we find out? ***Creative thinking:*** What other ways might we get to school? If you could choose any mode of transport, what would it be and why? ***Caring thinking:*** Why might it be more difficult for some people? Why might some people prefer other ways? ***Collaborative thinking***: Can we work together to think of a better way to get to school? ***http://21stcenturylearners.org.uk/wp-content/uploads/2019/07/4Cs.xls***
Science Capital Teaching Approach A reflective framework that involves making small changes to re-orientate science lessons in ways that	The approach is based on the foundation of broadening what counts as ways of doing science and comprises three pillars: **Personalising and localising** (Making science personally	The framework enables children to become self-aware and can be used to help children consider how science can be used in their	Supports greater purpose to science learning and enquiry, ensuring it is relevant to children and their future.	**Using Electricity** **What do you know?** e.g. What is electricity? How does a circuit work? How can we use electricity safely? **What do you do?** e.g. What devices do you use at home which use electricity?

better connect with the reality of students' lives and experiences, Archer (2018).	relevant to their lives and their communities) **Eliciting, valuing and linking students' experiences, identifies and what matters to them, with science** (Helping students to make sense of and relate to science) **Building Science Capital** (seeing how science knowledge and skills can be used in a wide range of roles and areas of life)	own lives and lives of others.		**How you think?** What would you like to know about electricity? What investigations would you like to do? Do you think we could use electricity differently? **Who you know?** e.g. Why is it important to understand how electricity works? Who needs to know about electricity in their daily lives? Which people use electricity in their jobs?
Critical thinking in primary science Engaging students in critique, argumentation and questioning, to build on their understanding and reasoning, Osbourne (2014).	**Support questioning and critical thinking by:** -Model question-asking. -Provide question prompts or stems. -Ask students to pose questions -Establish a question corner in the classroom to supply 'questions of the week'. -'Brainstorm' sessions; -Include question-asking in evaluation. -Use interactive instructional approaches where students work in collaborative groups to generate questions. Create a non-threatening classroom atmosphere where students feel free to ask questions.	Critical thinking	Critical thinking is central to the development of scientific knowledge and the ability to reason scientifically (Osborne, 2014).	**<u>Scientific enquiry question stems</u>** What did you find out? What did you not find out? Can you say why you think that? Can you give an example? Can you think of any exceptions? What might someone who disagrees with you say? How does that help us answer the question? What would you differently if you did it again?
Creative thinking in primary science Divergent thinking: the ability to come up with new, original ideas and the antipathy of critical thinking, which involves scrituny of given information, data or evidence of some kind (McGregor, 2019).	To be creative, children are required to be involved in: -Exploration; Enquiry; Explanation; Making connections.	Creative thinking	Opportunities to emphasise independent scientific thinking before, during and after enquiry to make connections.	**<u>Odd one out</u>** Children are presented with three images and are asked to identify which one they think is the odd one out, justifying their reasoning so revealing their thinking and their perspective. **<u>Big Questions</u>** Where did the mass of a large tree come from? **<u>PMI (Positive, minus, interesting)</u>** People have their own plant-like green skin, so they can create their own food in sunlight. Positive – Food would be more accessible rather than based on who can access / afford it. Minus - You might get a sugar rush if you lie in the sun! Interesting – Would diabetes still be a problem?
Practical action STEM, science, design and technology resources fit the UK curriculum and engage children in real world issues including climate	Using a global context to inspire and engage young people in STEM subjects. Its resources help raise awareness of problems faced by communities around the world and give a positive image of	Materials are set within a global context, and many explicitly link to the UN Sustainable Development Goals (SDGs). They focus on	Scientific enquiry is underpinned by a context-based problem / challenge.	**<u>Floating gardens</u>** The activity supports children to learn about the difficulty that farmers in Bangladesh and the UK experience trying to grow crops on land that is regularly flooded. Children are challenged to make a model of a floating

change, renewable energy, food security and disaster preparedness. https://practicalaction.org	scientists and engineers from those countries.	supporting children to create innovative solutions to real world problems.		structure/garden that farmers can grow their crops on. This challenge reinforces concepts of forces (floating and sinking).

Appendix IX. Table of initial semi-structured interview participants

	Role	GLPS CPD	Further details
1	Advisor 1	No	PSTT fellow/ PSQM hub leader
2	Advisor 2	No	Primary Science consultant
3	Advisor 3	No	Royal Society
4	Advisor 4	No	STEM learning
5	Advisor 5	Yes	Curriculum designer
6	SLT (Head teacher 1)	No	Partnership school
7	SLT (Head teacher 2)	No	Partnership school
8	SLT(Deputy head 1)	No	Partnership school
9	SLT(Assistant head 4)	No	Partnership school
10	SLT (Executive head 5)	No	Partnership school
11	SLT (executive head 6)	No	Partnership school
12	SLT (head teacher 7)	Yes	MPS (Whole school inset)
13	HOD no. 1	Yes	Case study school A
14	HOD no. 2	Yes	Case study school B
15	HOD no. 3	Yes	Case study school C
16	HOD no. 4	No	Partnership school
17	HOD no. 5	No	Partnership school
18	Teacher no.1	No	NQT
19	Teacher no. 2	Yes	NQT
20	Teacher no. 3	Yes	KS2
21	Teacher no. 4	No	NQT
22	Teacher no. 5	No	KS1
23	Pre-service teacher no. 1	Yes	BA ED
24	Pre-service teacher no. 2	Yes	BA ED
25	Pre-service teacher no. 3	No	PGCE
26	Pre-service teacher no. 4	No	PGCE
27	Pre-service teacher no. 5	Yes	PGCE

Appendix X Examples of transformative learning in primary science

Appendix XI Reflective diary entries

XIIa **Date**: 02.07.18
Event: Pilot Workshop with a range of stakeholders (Senior leader, teacher, graduate student, STEM consultant, and primary science lecturer)

What: What have I learnt? What did I hope to learn? What surprised me?	All participants demonstrated an enjoyment and interest in the workshop and agreed with the potential in raising both science and global learning in primary schools. Stakeholders were helpful in making suggestions in improving the workshop coverage / pace / activities.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt	All activities were well received, but it was evident that more time needed to be taken for these in order for meaningful learning to take place. Consider different ways to support CPD learning of SDGs – perhaps go through these before the activity where teachers need to link them to areas of the curriculum – it was surprising how many of the group were unaware of the SDGs and enjoyed relating them to the science curriculum.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science? Now what might be the consequences of this action?	Make use of twitter to share ideas related to global learning in primary science education (most used platform for younger teachers) Continue to build website/ blog platform to facilitate ideas in linking primary science and global learning. Provide highlighters for identifying key words from different country curriculum aims – a suggestion that a collaborative wordle could be created by asking teachers to send their 10 most significant words from the different curricula and sending these on their smart phones Integrate time in workshop to go through the main aspects of the SDGs and ensure that the related questions are in child-friendly language Ensure all of the resources are laminated and reusable to ensure that I am demonstrating / modelling my own values.
Additional comments	MV (student teacher is happy to be contacted to find out how she applies the ideas for the session). Read articles by Tim Oates (SSR, curriculum and international comparison) https://doi.org/10.1080/09585176.2011.578908 https://policyexchange.org.uk/wp-content/uploads/2016/09/knowledge-and-the-curriculum.pdf pg 55 Contact SE, who has been working on integrating global learning across her science curriculum.

XIIb **Date**: 02.07.18
Event: Recruiting schools to participate in research

What: What have I learnt? What did I hope to learn? What surprised me?	Recruiting schools has been more challenging that first expected. It could be the time of year and means of contacting schools. It could also be the area of research, when schools need valuable time for imminent foci, e.g. English, Maths, phonics, assessment, etc.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt	Consider marketing research in a different way to recruit schools – e.g. emphasise the potential impact on English and Maths? Ask schools what they would like in terms of workshops and fit this within their requests / needs? Consider recruiting individual teachers / heads of science rather than whole schools.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the care I give to my patients?	Consider other ways of recruiting schools / teachers to participate in research? This needs to be part of the literature – considering how teachers and schools engage with subject-specific research.
Additional comments	Consider the potential to work with ITE students to ensure that they continue to engage with subject-specific professional development beyond their training, e.g. in NQT year. Work with NQT teachers who are interested in global learning in science education.

XIIc **Date**: August 2018
Event: Global learning Attitude Survey conducted with Newly Qualified Teachers.

What: What have I learnt? What did I hope to learn? What surprised me?	30 NQTs completed the survey out of a possible 50. This is a good return rate, an demonstrates an enthusiasm to support research at an early career stage. 15 of the 30 responses wished to be contacted to inform of them of further research workshops related to global learning.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt	Chase up those interested in further support/ Consider how to engage early career practitioners/
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	Follow up the 15 respondents who are happy to be contacted regarding continued information about global learning. If possible, ask to track these students over the course of the year to explore their engagement with global learning in relation to science.
Additional comments	This survey needs to be analysed fully, but from an initial analysis, it is evident that 100% have a positive attitude towards global learning in science education, with over 60% requesting additional support on the area. This is both hopeful, but it will be interesting to see if this pattern of enthusiasm can be sustained when these teachers are submerged in their own school systems.

XIId **Date**: 3rd Sept 2018
Event: Exploring different ways of engaging schools and teachers to participate in the global learning CPD

What: What have I learnt? What did I hope to learn? What surprised me?	It is evident that there has been a low interest in the uptake of schools holding a global learning in primary science CPD workshop
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt	This confirms research regarding why and how CPD is delivered and taken up, and how science is low on the priority list for both senior leaders and for schools in general.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science? Now what might be the consequences of this action?	In order to get research participants, I have realised that it is important to explore different avenues of recruiting schools and teachers: 1. Consider how the workshop is marketed, to appeal to different groups of teachers. Research identifies that teachers need to see how any CPD is going to impact on the performance of their pupils, so perhaps this needs to be emphasised. 2. Consider how to contact schools and teachers – research also identifies how schools and teachers choose CPD based on quality and reputation. It is, therefore, important to approach schools and teachers whom we have already built a professional relationship with. I have, therefore chosen to approach schools and teachers within the primary science network. 3. I have also decided to use different avenues to connect with schools including wider CPD events and conferences.
Additional comments	Connecting with teachers at different stages of their career to ask them how and why they take up different CPD, and its impact on their career development in relation to science, may be significant in my group interview stage.

Date: 06.09.18

XIIe **Event**: SE – interview.

What: What have I learnt?	Strategies used in school: • Global learning underpin the principles of science in the school

What did I hope to learn? What surprised me?	• School embraces outside resources – e.g. practical action, water explorers • Leicester borough has an eco-education coordinator, encouraging all local schools to get their green flags. • School embraces a range of national initiatives including being a fair trade school, doing fair trade fortnight • School has a fairtrade eco-club • PSQM allows the school to invest in embedding global learning into the science curriculum • Champion children who do not excel in academic subjects • Raises the sense of community and ensures children respect and value all members of their school community • Makes science relevant and nurtures independence • Develops problem solving through relating science to real life issues • Children feel valued and have a purpose • Supports children who have English as a second language – Sandfield Primary had 90% EAL and found that embracing global learning in science allowed children to access their learning more readily. • Supports staff and parents – awareness raising • Unique nature of school • Same head of science for 10 years • Lots of teachers have left to become science leaders in their own right • Teachers all embrace global learning in science – hard to avoid as the children are exposed to global learning in lots of different ways – e.g. assemblies, clubs, etc.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	Importance of commitment from all stakeholders, especially the head teacher and leadership team valuing and investing in global learning and related CPD for teachers Importance of drawing on local relevance of global learning, considering local demographic, cultures, etc. Ensuring teachers have an authentic understanding of the SDGs Importance of ensuring English and maths are established and grounded before a school has the capacity to embrace opportunities in areas of learning such as science Consideration of how global learning in science can break down barriers.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	Interview head teachers? Talk to LJ (@ecoschoolsleicester who has a group of schools who work together on global issues Explore practical action activities and how they can support learning in science Explore water explorers initiative.
Additional comments	Use SF Primary School, Leicester as a case study, possibly visit school?

XIIf **Date**: October 2018
Event: Case Study School A workshop reflection

What: What have I learnt? What did I hope to learn? What surprised me?	During the two-hour workshop, I wanted to identify teachers' views about global learning in primary science education, and how they might apply the ideas to their own curriculum. The teachers and headteacher were very positive about the workshop and enjoyed the activities. They were able to
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	It appeared important that the head teacher was at the workshop, encouraging the teachers to consider the global learning dimensions of the science curriculum. It also appeared significant that many of the teachers had worked in developing countries as part of a school scheme to widen their perspectives of pedagogy around the world. Being supported to widen perspectives and develop new pedagogical strategies needs to be supported from the senior leadership team.

	However, it was also apparent that teachers needed additional support to consider ideas of how to implement activities and strategies. As a result, their default was to use global learning in science as a bolt on – (science week / international week). I was happy to support this, and wondered if doing so would develop teacher awareness and thus enable further integration within learning?
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science? Now what might be the consequences of this action?	Develop a range of materials that enables teachers to integrate pedagogy and activities within their teaching. Provide opportunities to work with teachers in order to develop ideas of how they can add a global learning dimension to their curriculum Consider readily available resources to direct teachers to when planning. Ask teachers if they would like support / examples of how to integrate global learning into their planning.
Additional comments	

XIIg **Date**: November 2018
Event: Case Study School B reflection

What: What have I learnt? What did I hope to learn? What surprised me?	During the two-hour workshop, there were a variety of experiences in the room, but this time the workshop was organised by the head of science, rather than the head teacher (no senior leadership were present). Although the staff were positive and appeared to enjoy the activities, without the direct support of the senior leadership team, the motivation to engage with the workshop in relation to the curriculum was more challenging. Teacher's appeared to enjoy trialling the activities and readily acknowledged their own progress of subject knowledge in science as well as how the strategies could be implemented in the classroom.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt	Within a school, important to have the support of the senior leadership team; Important to consider the focus / targets of the school (i.e. school development plan / priorities)
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	Develop / support summer of STEM workshops / activities to demonstrate and model how global learning can be used to engage children in science – follow this up. These ideas (immersion, inquiry and innovation) could be applied as a model for science week and science learning to ensure the integration of elements of global learning. Make these available to other schools – an easy way
Additional comments	Follow up with the head of science will be useful

XIIH **Date**: November 2018
Event: Case Study School C

What: What have I learnt? What did I hope to learn? What surprised me?	The session was interesting as the inset was lead by the head of science after one to one training by myself. The team were dedicated and interested in how they could adapt their schemes of work.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this?	The teachers seemed to enjoy the world science aims activity – One teacher said 'this really helped me to see that there is science beyond our curriculum, that not all science curriculum have the same aims – it helped me to pick the aims that really resonated with me.' Another teacher:

So what was different to what I knew previously?	'I suppose I took for granted that science wasn't the same in different countries. It was exciting to see different ways other countries approached science'. And finally: 'Although we know it is important to ensure we are covering the programmes of study [of England, DfE, 2013] reading the aims of other country curriculums inspired us to consider wider aims in developing global citizens'.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	The school was going to go away and work with SLT and other teachers to consider purposeful themes for their science schemes of work. The head of science was going to lead the planning meetings and consider how to ensure the science was delivered effectively. We arranged a follow up meeting in the new year.
Additional comments	Follow up with the head of science to be arranged.

XIIi **Date**: November 2018
Event: Global Learning in Primary Science Resource development.

What: What have I learnt? What did I hope to learn? What surprised me?	Although there is a lot of resources available (see new GLPS resource sheet), these do not always have a clear curriculum / working scientifically focus. I recognised that my own colleagues were averse to integrating new pedagogical approaches into trainee programmes, choosing to focus on the central aims of the curriculum which was important for Ofsted ITE framework
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	Help teachers to make the links between available resources and how it can fit into the curriculum in order to achieve specific learning outcomes
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science? Now what might be the consequences of this action?	Develop online support further to demonstrate how curriculum objectives can be achieved through resources/ global learning focused activities.
Additional comments	

XIIj **Date**: 09.05.19
Event: Academic Network of Global Education and Learning

What: What have I learnt? What did I hope to learn? What surprised me?	The conference gave me an opportunity to network with others who were exploring ways of developing a larger global learning emphasis in international education. Several organisations and journals are worth keeping up-to-date with in relation to this work: • British Council: Connecting classrooms

So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	It is important to be aware of the neo-liberal hegemony critique, As DFID (2018) state, there is a need for global learning to be rooted or strongly linked to the curriculum. This provides a clear argument for this research. Develop a better understanding of curriculum (Specified, enacted and experienced) – as explored by the open university, 2008) Using the model: - Aware, explain, grow act; person, others, socityu,global
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science? Now what might be the consequences of this action?	To read: • Develop a stronger understanding of Agentic educator – Coehlo, Carameh and Menezes (2018) • Tarozzi, M, (2018) Implementing global citizenship into EU primary schools
Additional comments	

Appendix XIII. Permission letter from Bamber, P.

On 14 February 2018 at 20:24, Amy Strachan <amy.strachan@stmarys.ac.uk> wrote:
Dear Philip,

I hope this finds you well. I am Ed Doc student (accredited through Hope) and senior lecturer at St Mary's University in Twickenham. I am very much inspired by your work and that of Andrea Bullivant, and would like to build on it within my role in primary science education. I'm currently writing up my research proposal which is currently entitled:

To what extent and in what ways can global learning be used as a vehicle to raise the profile of science in primary schools

My research will involve working with leaders of primary science education to explore different ways of taking ownership of the primary science curriculum by embedding global perspectives / values and attitudes related to global learning.

I want to explore different ways to help teachers link their personal values / attitudes / concerns with their practice. As a result, I would like to use an adapted version of the survey identified in your paper:

- International Journal of Development Education and Global Learning 5(3) 2013

Would you be happy for me to do this and are you happy for the weightings of the survey to remain the same?

Best wishes,

Amy

--
Dr Phil Bamber

Associate Professor / Head of Department

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Philip BAMBER <bamberp@hope.ac.uk>
Sun 25/02/2018 21:12

Dear Amy,
So sorry not to get back to you sooner. That would of course be fine.
Let me know if you need any specific info - or would like to discuss if further.
I would be interested to hear how you get on with your research.
all the best
Phil

Appendix XIV Ethics Approval

St Mary's University Twickenham London

3 April 2018 SMEC_2017-18_098

Amy Strachan (ETL): 'To what extent, and in what ways, can global learning be used as a vehicle to promote science in primary schools?'

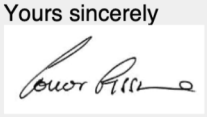
Dear Amy

University Ethics Sub-Committee

Thank you for re-submitting your ethics application for consideration.

I can confirm that all required amendments have been made and that you therefore have ethical approval to undertake your research.

Yours sincerely



Prof Conor Gissane
Chair, Ethics Sub-Committee

St Mary's University, Waldegrave Road, Strawberry Hill, Twickenham, London TW1 4SX
Switchboard 020 8240 4000, Fax 020 8240 4255, www.stmarys.ac.uk

St Mary's University Twickenham London

To what extent and in what ways can global learning be used as a vehicle to raise the profile of science in primary schools?

Focus Group Question Areas

Focus group 1: After workshop

1. Reflections from the workshop
    a. Do you feel differently about global learning and its application to the primary science curriculum?
    b. How do you feel about using some of the ideas within your teaching?
    c. How did you feel about the session in general? What (if any) impact might it have on your practice?

2. How might you use the information / skills / ideas from the session in your school?
    a. How might you share them with colleagues?
    b. How might you embed them within your science curriculum?
    c. How will you evidence their impact?

3. Do you use any of the strategies shared in today's workshop in your current practice? If so, how?

Focus group 2: After a term during which teachers have trialled ideas

1. Has your practice in science changed since the workshop?

2. If so, how has your practice in science changed?
    a. Do you plan differently?
    b. What strategies do you use?

3. Can you give some examples of how you have embedded global learning in science lessons?
    a. How did you feel? Did you enjoy it?
    b. What do you think the impact was on the children's learning? How do you know?

4. Have you shared the ideas / approach with colleagues?
    a. How have you done this?
    b. Have you observed any change of practice?
    c. What has been the impact on the teachers / their students?

5. What will you do now? Will you develop / embed global learning in your practice?

Appendix XV: Survey

Global learning survey

Attitudes towards global learning in primary science education

1. I think that it is really important for young people to know what's going on in the world ☐

2. Having a global dimension to science learning is totally pointless and would detract from my important learning ☐

3. Global learning in science is absolutely essential for the development of myself and those I teach ☐

5. Whilst creative thinking is important there are things in science which take a higher priority ☐

4. Global learning is a low-priority issue on the scale of what is important in my life and my work ☐

6. Global learning adds to pupil learning of science ☐

7. I think global learning is significant but honestly don't know if it is more or less important than Mathematics or English ☐

8. Young people should be aware of different perspectives in science ☐

9. Global learning in science is too complex to engage with ☐

10. Incorporating global learning in science is beyond the role/scope of being a teacher ☐

11. I hate the whole idea of integrating global learning into science lessons ☐

12. Whilst global perspectives in science learning could be important, the concept may need further clarification to be usefully applied to the science curriculum ☐

13. I am passionate about global learning in science☐

14. Global learning in science is possibly one way to promote critical thinking ☐

Adapted from Bamber, P. (2013) Measuring attitudes towards Global Learning among future educators in England. International Journal of Development Education and Global Learning 5(3) 2013

V6 November 2016

St Mary's University

Ethics Sub-Committee

Application for Ethical Approval (Research)

This form must be completed by any undergraduate or postgraduate student, or member of staff at St Mary's University, who is undertaking research involving contact with, or observation of, human participants.

Undergraduate and postgraduate students should have the form signed by their supervisor, and forwarded to the School Ethics Sub-Committee representative. Staff applications should be forwarded directly to the School Ethics Sub-Committee representative. All supporting documents should be merged into one PDF (in order of the checklist) and clearly entitled with your **Full Name, School, Supervisor.**

Please note that for all undergraduate research projects the supervisor is considered to be the Principal Investigator for the study.

If the proposal has been submitted for approval to an external, properly constituted ethics committee (e.g. NHS Ethics), then please submit a copy of the application and approval letter to the Secretary of the Ethics Sub-Committee. Please note that you will also be required to complete the St Mary's Application for Ethical Approval.

Before completing this form:

- Please refer to the **University's Ethical Guidelines**. As the researcher/ supervisor, you are responsible for exercising appropriate professional judgment in this review.
- Please refer to the Ethical Application System (Three Tiers) information sheet.
- Please refer to the Frequently Asked Questions and Commonly Made Mistakes sheet.
- If you are conducting research with children or young people, please ensure that you read the **Guidelines for Conducting Research with Children or Young People**, and answer the below questions with reference to the guidelines.

Please note:

In line with University Academic Regulations the signed completed Ethics Form must be included as an appendix to the final research project.

If you have any queries when completing this document, please consult your supervisor (for students) or School Ethics Sub-Committee representative (for staff).

St Mary's University Twickenham London

Participant Research Information Sheet

To what extent and in what ways can global learning be used as a vehicle to raise the profile of science in primary schools?

Purpose

The purpose of this Doctoral research is to explore the ways in which global learning can be integrated into primary science education and whether this has an impact on teacher and pupil attitudes towards the subject.

Background

The Science National Curriculum in England (DfE, 2013) provides a framework of 'what' should be taught. However, the programmes of study are designed to leave schools and teachers with the scope to use their professional talents and skills to develop schemes of work which puts the understanding of science concepts and their application in a real context. Since the eradication of the Science SATs in 2009, there has been a significant decline in the number of hours dedicated to science teaching in primary schools. This study aims to explore the extent to which and in what ways global learning can be used as a vehicle to raise the profile of science in primary schools.

Invitation

We would like to invite you to participate in an action research study, exploring how global learning can be integrated into the science curriculum in your school.

The study will involve the following stages (over the academic year, September to July):

1. An initial survey to explore your current understanding of global learning and your perceived relevance of its place in primary science education (this will take no longer than ten minutes);
2. A science and global learning workshop (2 hours);
3. An opportunity to participate in a semi-structured interview (via phone or face-to-face) to discover your views and ideas about primary science (approximately 30 minutes);
4. An opportunity to feedback on any reflective insights into the use of global learning in primary science in your classroom / school (approximately 30 minutes);
5. Interviews will be audio recorded for analysis purposes. All audio recordings will be held securely on St Mary's University server, with only research access, and will be destroyed after the study.

The results of the study will allow us to develop professional development sessions to support teachers and trainee teachers to integrate global learning into primary science. Not only will this allow us to consider how to support future teaching practice, but it will help to inform future primary science ITE. However, the data collected from this project will remain confidential, and schools and teachers will remain anonymous. You are free to withdraw from the research at any time, by informing the primary contact (detailed below).

The aim is for the process to be purposeful to your own professional development and that of the teachers within your school. We hope this information sheet has answered all of your questions, but do not hesitate to ask if you have any more. If you agree to participate, please complete the attached consent form.

Amy Strachan amy.strachan@stmarys.ac.uk (Primary contact)
Dr. Caroline Healy caroline.healy@stmarys.ac.uk (supervisor)

School of Education, Theology and Leadership
St Mary's University, Waldegrave Road, Twickenham, London TW1 4SX.
www.stmarys.ac.uk
March 2018

St Mary's University Twickenham London

APPENDIX 2 : CONSENT FORM

Name of Participant: _____

Title of the project: Global learning in primary science education

Main investigator and contact details: Amy Strachan amy.strachan@stmarys.ac.uk

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print).....

Signed..... Date.....

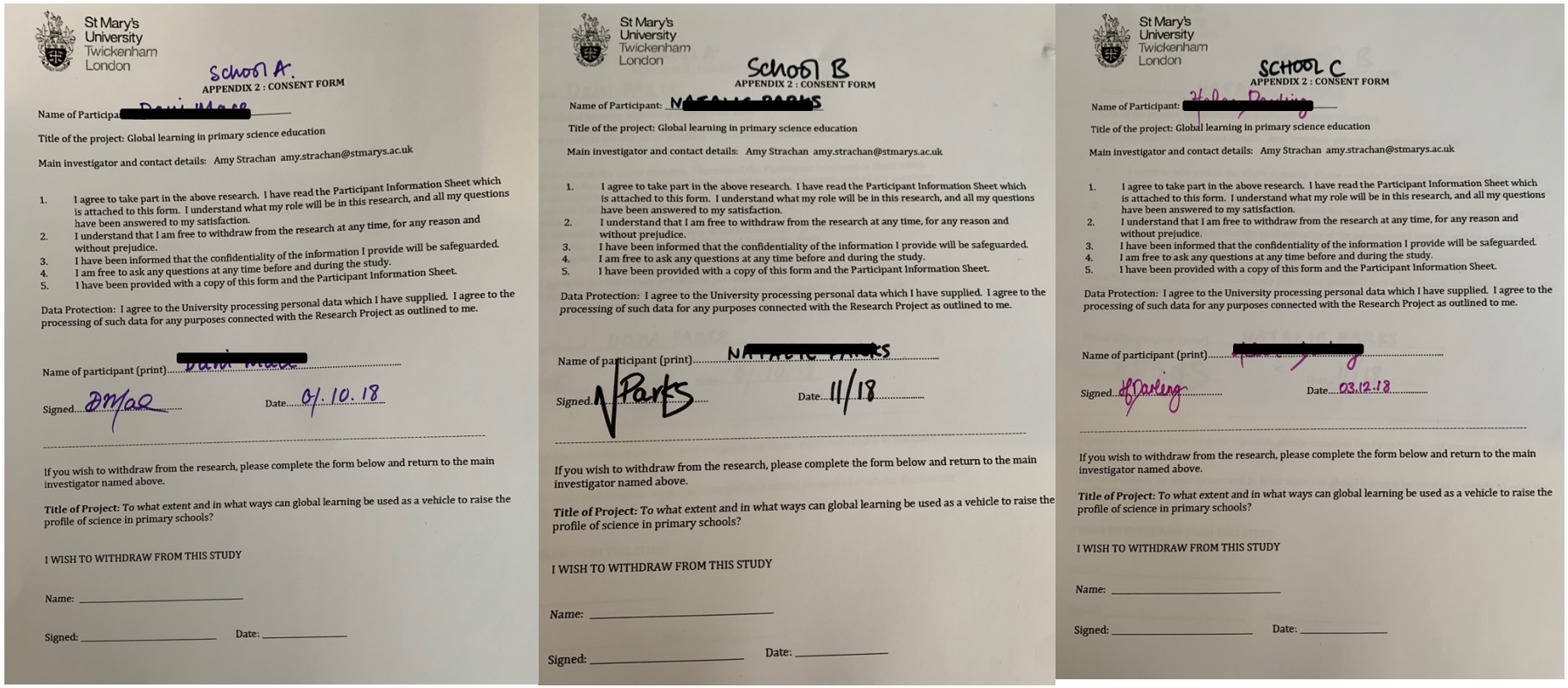
If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: To what extent and in what ways can global learning be used as a vehicle to raise the profile of science in primary schools?

I WISH TO WITHDRAW FROM THIS STUDY

Name: _____

Signed: _____ Date: _____



St Mary's University Twickenham London

School A.

APPENDIX 2 : CONSENT FORM

Name of Participa[redacted]

Title of the project: Global learning in primary science education

Main investigator and contact details: Amy Strachan amy.strachan@stmarys.ac.uk

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)[redacted]

Signed... Date... 01.10.18

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: To what extent and in what ways can global learning be used as a vehicle to raise the profile of science in primary schools?

I WISH TO WITHDRAW FROM THIS STUDY

Name: _____

Signed: _____ Date: _____

St Mary's University Twickenham London

School B

APPENDIX 2 : CONSENT FORM

Name of Participant: [redacted]

Title of the project: Global learning in primary science education

Main investigator and contact details: Amy Strachan amy.strachan@stmarys.ac.uk

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)[redacted]

Signed... Parks Date... 11/18

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: To what extent and in what ways can global learning be used as a vehicle to raise the profile of science in primary schools?

I WISH TO WITHDRAW FROM THIS STUDY

Name: _____

Signed: _____ Date: _____

St Mary's University Twickenham London

SCHOOL C

APPENDIX 2 : CONSENT FORM

Name of Participant: [redacted]

Title of the project: Global learning in primary science education

Main investigator and contact details: Amy Strachan amy.strachan@stmarys.ac.uk

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)[redacted]

Signed... Date... 03.12.18

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: To what extent and in what ways can global learning be used as a vehicle to raise the profile of science in primary schools?

I WISH TO WITHDRAW FROM THIS STUDY

Name: _____

Signed: _____ Date: _____

Appendix XVII Individual interview profiles

	Role	GLPS project CPD	Further details	What is the participant trying to tell me?
1	Advisor 1	No	PSTT fellow/ PSQM hub leader/ classroom teacher	Having a dual role of teacher and adviser, this participant appears to embrace opportunities in her practices with a global dimension. A personal engagement in GL appears to be a motivating factor to ensure authentic engagement, as it first-hand evidence of the impact it has on children's learning.
2	Advisor 2	No	Advisor providing independent resources related to primary science	This participant is a clear advocate of GL in primary science, but obviously sees a contention between their vision and the NC programmes of study – suggesting that advisors and consultants need GL to be in policy in order to value it.
3	Advisor 3	No	Royal Society	The clear message from this participant is advocating teachers / trainee teachers themselves to see themselves as professionals (perhaps suggesting that teachers themselves need to see themselves as global learners?)
4	Advisor 4	No	STEM learning	This advisor was very hesitant about using SDGs as a framework due to teachers not having the security and confidence of subject knowledge to make effective links.
5	Advisor 5	Yes	Curriculum designer	As a curriculum designer, it was clear that this participant was highlighting the importance of the teacher's role in delivery rather than design of the curriculum.
6	SLT 1	No	Head teacher	Belief that the curriculum content is too much to cover, and although trial and error, critical thinking and problem solving are important, there just isn't enough time.
7	SLT 2	No	Head teacher at one-form entry primary	An emphasis on outdoor learning – but would like more resources and training for staff to integrate global / outdoor learning with confidence.
8	SLT 3	No	Deputy head	This conversation focused on the importance of covering the programmes of study and supporting the teachers to have confidence to deliver a curriculum which developed critical thinking, independence and problem-solving skills.
9	SLT 4	No	Assistant Headteacher	Schools need to go beyond the N/C requirements – therefore this teacher highlights that they already use P4C and an ethos of sustainability, but global learning should be an integral expectation of good science teaching.
10	SLT 5	No	Executive head teacher	Although programmes of study give teachers the opportunities to make links, these are not explicit, and teachers need more guidance to relate real world science issues with confidence.
11	SLT 6	No	Executive head teacher of three schools	Quality and integral values of the science curricula depend on teachers' confidence and capacity to integrate ideas, keeping teachers fully informed of new initiatives, science developments and world issues.
12	SLT 7	Yes	MPS (Whole school inset)	This headteacher showed real passion about embracing this initiative and supporting her staff to develop their expertise in global learning, with an exchange initiative to support her teachers.
13	HOD 1	Yes	MPS (Whole school inset) Early years and science lead in a one form entry school	Teachers lack confidence to embrace such initiatives and therefore stick heavily to the curriculum. Teachers need support and resources to help them.
14	HOD 2	Yes	Head of science in three-form entry primary with attached secondary.	HOD personally an advocate of integrating GL into science curriculum and already bases programmes of study around GL themes, e.g. rainforests, but she is worried that her team will be more reluctant and will want to stick to schemes of work they have invested in.
15	HOD 3	Yes	Two form entry primary school Head of Science	This head of science feels that they need to develop their own knowledge of SDGs before supporting colleagues. She said she thinks some will be more open than others.

			(Recently qualified teacher)	
16	HOD 4	No	PSQM leader (leader of primary science in same school for over ten years)	This head of science conveyed the importance of convincing SLT and parents of the value of Global learning in primary science – an important perspective in relation to perspectives.
17	HOD 5	No	Partnership School (three form entry)	A real contention between own beliefs and capabilities of general primary teachers – thinks they need to develop subject knowledge confidence before integrating new strategies.
18	Teacher 1	No	NQT	More support, lesson ideas and accountability from SLT / HOD to motivate the integration of new initiatives.
19	Teacher 2	Yes	NQT	This teacher demonstrated the importance of being supported by seeing good practice / lots of practical examples of how science learning should look.
20	Teacher 3	Yes	KS2	Resources, support and schemes of work necessary to embed global learning in science curriculum. This teacher was excited about the cross-curricular approach to GL.
21	Teacher 4	No	NQT	A real emphasis on the need for external science advisors to support school science on a more regular basis.
22	Teacher 5	No	RQT	An emphasis on the importance of building confidence about teaching science as well as understanding how to use global learning to enhance what needs to be taught – with quality resources and training available during NQT and RQT years.
23	Pre-service teacher 1	Yes	BA ED student	Significant emphasis on how student would be motivated if SDGs / GL was part of the teaching standards and how lesson planning in university has too much of a focus on outcomes and achievement, rather than the bigger picture.
24	Pre-service teacher 2	Yes	BA ED student	Would like a better understanding of where to access information to keep abreast of changes and developments in science – feels it is really important but doesn't know how to keep informed – are there any go-to websites to support this approach.
25	Pre-service teacher 3	No	PGCE student	More modelling of effective pedagogical strategies would be great – motivated to integrate more initiatives but lacks time due to workload as a trainee teacher. L;
26	Pre-service teacher 4	No	PGCE student	Global learning might help make science topics more interesting to teach, as some of the programmes of study could be more engaging. This student would like more guidance regarding current global issues in relation to science
27	Pre-service teacher 5	Yes	PGCE student	This student would like more support / modelling of how to teach practical and enquiry-based lessons with a global learning dimension.

Appendix XVIII Reflective diary entry

Date: 07.01.19
Event: ASE Conference global learning in primary science workshop

What: What have I learnt? What did I hope to learn? What surprised me?	19 delegates – a real interest in the approach I wanted to gain an awareness of the value of the approach for experienced practitioners in primary science It was very reassuring that many of the delegates were already incorporating a wide range of strategies and concepts in line with the approach. Delegates were both relieved as they were doing many of the aspects already (such as enquiry, communicating evidence, listening to each other's perspectives)
So What:	All delegates were reassured by the parallels between the global learning approach and best practice in primary science.

So what is the importance of this learning? So what more do I need to know about this? So what have I learnt	Now need to know how to elicit and embed this from an ITE level to ensure that it is not left to chance.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	Aligning the approach with the National curriculum, as well as helping practitioners make small adaptations to their best practice would embed the global learning approach. On a bigger scale, considering how to make the ideas more explicit in policy would help to formalise the approach, rather than leaving it to chance, giving teachers are shared understanding of the approach – relating it to their shared values.

Date: 09.01.20
Event: ASE Conference global learning in primary science workshop

What: What have I learnt? What did I hope to learn? What surprised me?	19 delegates – a real interest in the approach I wanted to gain an awareness of the value of the approach for experienced practitioners in primary science It was very reassuring that many of the delegates were already incorporating a wide range of strategies and concepts in line with the approach. Delegates were both relieved as they were doing many of the aspects already (such as enquiry, communicating evidence, listening to each other's perspectives) A discussion with a group of SLT members highlighted that they felt that the third aim of the National Curriculum was not fully developed, and this approach would support them to achieve it – but difficult to measure.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	All delegates were reassured by the parallels between the global learning approach and best practice in primary science. Now need to know how to elicit and embed this from an ITE level to ensure that it is not left to chance. Time is so limited; I don't know if teachers have the confidence with their science subject knowledge or sustainable development goals to teach them together simultaneously
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	Aligning the approach with the National curriculum, as well as helping practitioners make small adaptations to their best practice would embed the global learning approach. On a bigger scale, considering how to make the ideas more explicit in policy would help to formalise the approach, rather than leaving it to chance.

Appendix XIX A frequency of overlaps between individual beliefs about primary science and the aims of the global learning approach:

Aspect of Global Learning in Primary Science Workshop	**Frequency of identification in activity one of GLPS workshops (40 individuals in total)**
Explore and make sense of the **big science issues** (big ideas)	0
Think critically and creatively about topical science (critical thinking, creativity, problem-solving)	6
Be **active participants** in science enquiry (discovery, enquiry, experiment, hands-on, investigation)	30

Consider **different perspectives to scientific ideas** (perspective, dialogic)	10
Communicate with and learn meaningfully about scientists from a range of cultures and countries (communicate, collaborate, team work)	6
Develop **an awareness of different approaches to scientific enquiry** (different approaches, scientific method)	12
Argue a **position** or view (position, view)	0
Reflect on the **consequences of their own actions** now and in the future (sustainability, environmental impact, respecting nature)	16
Link science learning to take **responsible action** (responsibility, innovation)	14

Appendix XX A summary of responses from all stakeholder groups to the attitudinal survey questions

Weighting	Statement	Advisors	SLT	HOD	Teacher	Pre-service Teacher
6.31	I think it's really important for young people to know what's going on in the world	30	30	30	30	30
1	Having a global dimension to science learning is totally pointless and would detract from important learning	0	0	0	0	0
6.85	Global learning in science is absolutely essential for the development of myself and those that I teach	12	13	18	21	26
2	Global learning in science is a low priority issue on the scale of what is important in my life and my work	7	3	3	0	4
3.08	Whilst creative thinking is important there are things which take a higher priority in science education	3	0	0	6	0
5.69	Global Learning in science adds to pupil learning	18	19	19	24	3
4	I think global learning in science is significant but honestly don't know if it is more or less important than Mathematics or English	4	2	2	7	7
5.38	Young people should be aware of different perspectives	24	26	26	26	26
2.08	Global learning in science is too complex to engage with	1	0	0	0	0
2.46	Incorporating global learning in science is beyond the role/scope of being a teacher	6	1	0	0	0
1	I hate the whole idea of teaching about global learning in science	0	0	0	0	0
4.23	Whilst global perspectives in science learning could be important, the concept may need further clarification to be usefully applied to the curriculum	17	10	10	14	12
6.85	I am very passionate about global learning in science	6	8	8	5	17
5.15	Global learning in science is possibly one way to promote critical thinking	25	14	14	19	25
(Frequency)	I am interested in participating further workshops about Global Learning in Primary Science	8	15	21	9	25
	Overall value	**5.212**	**5.69**	**5.763**	**5.584**	**5.767**

Appendix XXI A Descriptive Statistics analysis of Attitudinal Survey of Global Learning in Primary Science

	Consultants	Pre-service Teachers	Heads of science	Teachers	SLT
Number of values	30	30	30	30	30
Minimum	3.478	5.300	4.384	4.892	4.384
25% Percentile	4.552	5.600	5.402	5.204	5.360
Median	5.349	5.800	5.825	5.602	5.746
75% Percentile	5.669	6.000	6.069	5.876	6.069
Maximum	6.283	6.200	6.600	6.348	6.600
Mean	5.212	5.767	5.763	5.584	5.694
Std. Deviation	0.6615	0.2537	0.4704	0.3962	0.5360
Std. Error of Mean	0.1208	0.04632	0.08589	0.07233	0.09786
Lower 95% CI	4.965	5.672	5.587	5.436	5.494
Upper 95% CI	5.459	5.861	5.938	5.732	5.894

Appendix XXII Tukey's multiple comparisons test highlighting statistical significance between different stakeholder groups

Tukey's multiple comparisons test	Mean Diff.	95.00% CI of diff.	Significant?	Summary	Adjusted P Value
Consultants vs. Pre-service Teachers	-0.5549	-0.9265 to -0.1834	Yes	***	0.0004
Consultants vs. Heads of science	-0.5510	-0.9225 to -0.1794	Yes	***	0.0004
Consultants vs. Teachers	-0.3721	-0.7437 to -0.0004940	Yes	*	0.0495
Consultants vs. SLT	-0.4820	-0.8536 to -0.1104	Yes	**	0.0034
Pre-service Teachers vs. Heads of science	0.003983	-0.3676 to 0.3756	No	ns	>0.9999
Pre-service Teachers vs. Teachers	0.1829	-0.1887 to 0.5544	No	ns	0.7159
Pre-service Teachers vs. SLT	0.07292	-0.2987 to 0.4445	No	ns	0.9931
Heads of science vs. Teachers	0.1789	-0.1927 to 0.5505	No	ns	0.7346
Heads of science vs. SLT	0.06893	-0.3026 to 0.4405	No	ns	0.9947
Teachers vs. SLT	-0.1100	-0.4815 to 0.2616	No	ns	0.9569

Appendix XXIII A summary of the principles and purposes of science education identified by different stakeholder groups using the OECD framework 2030 to categorise knowledge, skills, attitudes and values.

	Knowledge	**Skills**	**Attitudes and values**
Advisor **Positive attitude towards GLPS: 3 out of 5 4.597**	Develop an understanding of the scientific process and foundation knowledge on which to build the big ideas of science (Wynne Harlen's big ideas). Promote science as a way of thinking; Cover the foundation knowledge that children need to build and develop new ideas. Develop scientific skills and make science relevant and meaningful.	Motivation begins at primary level - understand how their learning relates to the bigger picture. Develop the skills, children need for future careers in science, especially more modern skills such as data handling, experimenting and researching. Develop curiosity about how the world around them work Develop transferable skills such as problem-solving and communication How science is applicable to the real world (both at a personal level and a wider world level Helps see what ' jobs' they might have the enthusiasm and skills for in the future	Explains to them how they can positively impact on the world they live in, and understand why their own actions are important (2)
SLT **Positive attitude**	To keep on learning and exploring with inquisition Develop investigative skills to learn how to answer their own questions and to learn how to	To ask questions and enjoy learning about the world around us To foster a sense of curiosity, wonder and awe of ourselves and the world in which we live	

towards GLPS: 2 out of 5 5.69	enquire about the world around them. So children can ask and answer their own scientific questions Provide them with the knowledge and skills to help them align their ideas with current scientific thinking, to ensure that misconceptions can be challenged. Science is important at a primary level to support individuals and their well-being – to live safely, e.g. hygiene, diet.	to awaken the children's minds to the wonder of our world Awe and Wonder to lay the foundation for future scientists develop awe and wonder and enquiry skills Awe and Wonder! If we hook children at primary then we at least have the foundation for future scientists! Exposing them to scientific knowledge and skills will enable them to meet economic needs and contribute to industry within their society.	
HOD **Positive attitude towards GLPS: 3 out of 5 5.763**	To develop a foundation of understanding for secondary, To be able to be more independent in answering questions about the world. ensure we have high quality teaching to cover the foundation understanding of the curriculum I suppose this means I want to track the knowledge and skill development so that children are prepared for secondary science. Prepare the children for their future study, whether this is common entrance exams, GCSEs, etc. However, there are many ways to do this to ensure the children are successful in their education.	A platform for science careers. We need to encourage children to pursue science careers in their futures and understand that these do not have to involve working in a lab. To give the children confidence in their developing understanding. Especially if they want to be scientists. Learning the skills that they can apply to all areas of life and learning. Also, learning about science in the real world, I think primary science education should be about empowering children to have the confidence to ask and answer questions about the world around them.	It provides the foundation to enable future generations to change and develop the world (1) Making the learning purposeful and personal to the locality (2)
Pre-service **Positive attitude towards GLPS: 5 out of 5 5.767**	It should develop children's understanding of the world and how it works! Making predictions, leading their own experiments and feeding back results to teacher and class as they discover them It should teach children how to ask a question and find out the answer in a systematic way.	To encourage children to explore and take responsibility in their learning Makes informed decisions and solve problems. It should teach children keys skills which are transferable throughout their learning	I think that it should enrich children and inspire them to build a better future (1) I believe it is to help children develop a passion for exploring the world around them (2)
Teachers **Positive attitude towards GLPS:** 3 out of 5 5.543	That children can recognise scientific procedures around them and within themselves. Understand how scientists work and how the world works. To have 'foundational' knowledge of how the world works and so they can understand concepts in later study Children to understand and appreciate the 'rational'/scientific outlook/search for true I think it is about helping children to understand the world around them.	To fascinate children about the world around them and to foster an interest about how it works as it facilitates a love for learning To "maintain curiosity" For future careers in science Promoting intrigue and curiosity	Because understanding the world allows children to make the most of it (1)

Appendix XXIV A table to share identified potential benefits of a global learning approach to primary science

Stakeholder group	Points raised related to attitudes and behaviours	Points raised related to knowledge and skill development
Advisors	4 (Sense of community, feel valued and have purpose, enjoyable to teach, motivating, holistic)	2 (Support access to understanding, problem-solving opportunity)

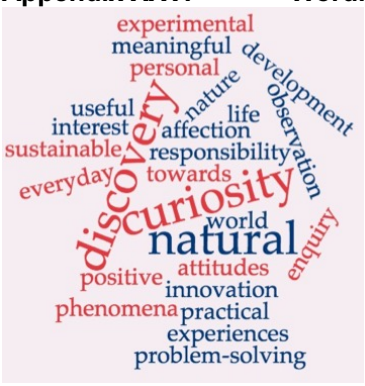
SLT	7 (curiosity, transferable, shows how children can make a positive impact, impact on the real world, sense of purpose)	0
HOS	5 (Sense of purpose, ownership, impact on real world, transferable, holistic)	0
Teacher	4 (memorable, realistic, real life application, ownership)	0
Students	4 (hooks, fosters interest, engaging, fun, interesting)	1 (Helps children understand)

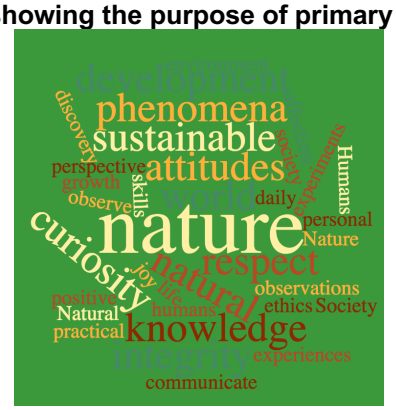
Appendix XXV Respondents beliefs about the attitudes and values primary science education should develop

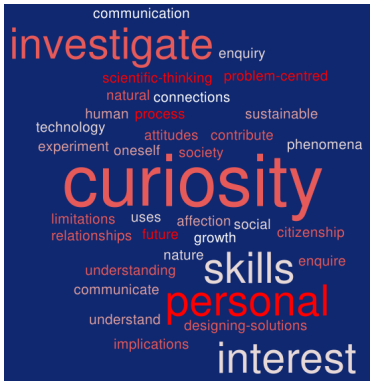
	Attitudes and values
Advisor 1	Problem-solving Feel valued and have a purpose
Advisor 2	Critical thinking Empathy for other people and circumstances around the world Develop positive attitudes to solving problems Interdependence as well as their ability / responsibility to find solutions to their own and other's problems
Advisor 3	Problem-solvers and know that there are different ways of looking at and solving problems; Ask questions and taught how to question things around them; Look at things from different perspectives.
Advisor 4	Problem-solving, resilience
Advisor 5	Values and attitudes should be decided by nation / community / school rather than the individual teacher.
Head teacher 1	Resilience, fairness, trial and error
Deputy head 1	Not to be afraid of making mistakes Opportunity to try things more than once in order to develop resilience
Head teacher 2	Resilience. Fairness and equity. Problem-solving skills, using trial and error.
Assistant headteacher (SLT) 4	Curiosity A sense of awe and wonder Questioning
Executive headteacher (SLT 5)	Stewardship for creation, respect for life, an ethical approach to use of scientific knowledge/ innovation.
Head teacher 6	Develop balanced enquiry (understanding there are different approaches and outcomes), critical thinking, evaluative responses based on findings.
Head teacher 7	Continue their learning at home, so equipping them with the skills to find out things themselves and share their ideas
Head of Science 1	Critical thinking and being able to question findings. Developing their attitude towards our planet and what we need to do to look after it / help save it.
Head of science 2	Develop problem-solving skills and critical thinking skills as these aspects are becoming more important in exams, as well as to use science knowledge effectively. Know how to use the information they obtain, both for their own lives and in their jobs.
Head of science 3	Know how to use their scientific knowledge and ideas flexibly. To be inquisitive and enjoy learning about the world around them.
Head of science 4	Learn to work together Learn to ask questions rather than take for granted what they hear (critical thinking) Learn to communicate their ideas with confidence.
Head of science 5	Nurture curiosity and the ability to ask questions. Adaptability and resilient in order to use the knowledge they acquire to solve different problems. Perseverance to continue to discover and not accept the status quo.
Teacher 1	Working hard in science through repeating experiments, being accurate, observing and recording carefully. Learn how to work as a team and to focus on an investigation/ experiment. Become resilient and keep trying new experiments and investigations to find things out.

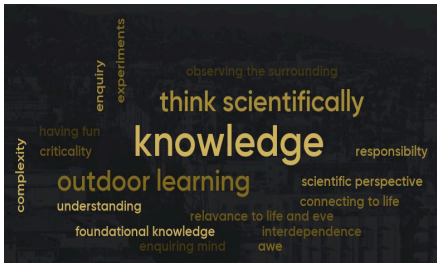
Teacher 2	Dispassionate desire to find 'truth' and being prepared to reconsider views in light of new evidence. (Criticality, different perspectives)
Teacher 3	A love of learning and discovery, an understanding and working as a team because discovery and science careers requires collaboration.
Teacher 4	Curiosity
Teacher 5	Nurture curiosity and the ability to ask questions and find out the answer in a systematic way
Pre-service teacher 1	A passion for exploration and investigation of the world around them They need the tools to make informed decisions about themselves and their environment
Pre-service teacher 2	Nurture an appreciation for the wider world and their place in it
Pre-service teacher 3	A respect and understanding of the world around them.
Pre-service teacher 4	Questioning, confidence, problem-solving
Pre-service teacher 5	Develops an enthusiasm for learning through motivating children to be curious about the world around them.

Appendix XXVI **Wordles showing the purpose of primary science education**









Appendix XXVI Reflective diary entry

Date: 09.01.20
School B Head of science reflective discussion extracts and reflections

What: What have I learnt? What did I hope to learn? What surprised me?	Head of science in school B was very excited about sharing their summer of STEM week with me. Although they did not use the global learning planning framework, the structure of the week fulfilled the various aspects. Interview question extracts: **What strategies have you implemented?** I ended up working backwards to see what knowledge the children would need to solve the global issue and realised these met a lot of the curriculum objectives' **What were the main impacts of implementing the approach?** 'It gave me a real opportunity to assess children's understanding in a more creative way' 'Once we tried it, we really saw the enthusiasm and engagement of the children. They really got into the projects and it felt really purposeful. **What were the main challenges?** 'The Senior Leadership team priorities were areas in their school development plan and science did not feature which was frustrating as I really wanted to have inset time to share these new ideas and initiatives'. **What additional resources / support do you need to implement the approach more effectively?** 'We wanted to use the global learning approach to empower the children, but it took a long time to make sure we had meaningful and authentic themes to underpin their knowledge and skill development. Having an advisor and planning time to do this really helped. We were really pleased with [our] planning.' In the year 3 planning meeting, one teacher highlighted that she had no idea where to look for information about materials that would be useful in the future.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	It was clear that without science being a priority in the school development plan, it was more difficult to emerge the approach in planning across the school – hence the creative use of a themed week. However the theme week forced the teachers to think about the approach in a holistic way. What was apparent was the lack of time teachers had to plan and resource with a new approach.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	It will be interesting to see if the success of the STEM week has an influence on the value of the approach towards SLT members in the future.
Additional comments	

Date: 03.12.19
Event: **Head of science (school c) reflective discussion extracts and reflection**

What: What have I learnt? What did I hope to learn? What surprised me?	**Interview extracts with head of science:** **What strategies have you implemented?** After my own professional development workshop with the science teachers to develop their global learning in primary science lens, we planned for each

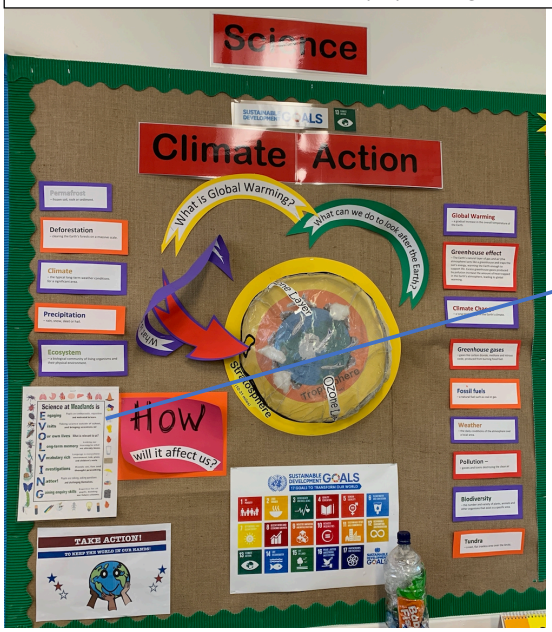
	lesson to have a critical thinking activity at the start and an application at the end (problem-solving / application to daily life). My colleagues highlighted these activities enabled children to listen to each other's ideas and show their scientific understanding. One teacher highlighted that this was the most useful aspect of the approach, getting children to see things from different perspectives. **What were the main impacts of implementing the approach?** I am excited to explore further opportunities for using global learning critical thinking activities as formative and summative assessment opportunities. I think it will help our children remember core ideas better' One teacher was surprised at how easy it was to incorporate a global learning approach to their science teaching.' I didn't think the SLT was going to be open to the new approach, but when they gave me and the team time to change the planning, I got excited about it' **What were the main challenges?** Initially other teachers in my school did not engage with changes in their planning and focused on the original content. Whilst in the first term, I saw positive impacts on pupil outcomes and engagement in my own lessons, I found it difficult to impose new approaches on colleagues who had been teaching for long periods'. As lots of the global learning approach involved discussion at the start and end of lessons, it was difficult to attain any evidence'. **What additional resources / support do you need to implement the approach more effectively?** 'Using the framework made me keep global competencies and global issues in mind when I was planning. It made me think more carefully about the type of activities the children would do and how they [the children] would work together.'
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this?	It is clear that until practitioners carry out the approach, they are more aware of the potential draw backs and constraints. Obtaining evidence of children's global learning may also be an inhibiting factor, because beyond improvements of standard assessments, it is difficult to measure. The teachers were excited to show me the children's work and their displays linking science to global learning.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	Consider examples of critical thinking activities which have a global dimension (illustrating the relationship between secure subject knowledge, critical thinking and global learning) for future workshops. For example, taking different country traditional meals and asking children to discuss which they think is most healthy – requiring them to draw upon knowledge of balanced diets, food groups, as well as learning that balanced nutrition can be gained in many different ways.
Additional comments	The head of science discussed how SLT had given planning time and this was the changing point, adding enthusiasm and giving her team thinking time to be creative about implementing global dimensions.

Date: 03.12.19
Event: **Head of science (school A) reflective discussion extracts and reflection**

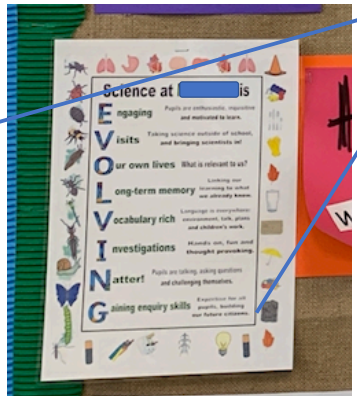
What: What have I learnt? What did I hope to learn? What surprised me?	Interview extracts with head of science: **What strategies have you implemented?** Each year group started off with an SDG that linked to the topics they were doing in science. We have displays in each classroom linking science to the sustainable development goals. As we are conducting a PSQM, it is also part of our principles and vision for science in our school. This has really helped us work together to achieve these. As the vision was part of my monitoring focus, teachers felt proud to show me what they had implemented. We began by identifying which sustainable development goals linked to the programmes of study being taught this term, which was easier than we thought. We were actually using many already without even realising it! Year 6 were looking at the impact of diet and exercise on their bodies, which was clearly related to sustainable development goal 3, good health and well-being. **What were the main impacts of implementing the approach?** 'If this was proposed a couple of years ago, when our numeracy and literacy progression scores were low, our head teacher wouldn't have been open to a new way of planning, but now we know our scores are good, we have space to be more creative in other subject' We have all really enjoyed giving our science teaching a purpose. Teachers have definitely spent more of their own time researching the bigger issues and learning alongside the children. **What were the main challenges?** I suppose time was the biggest issue both in terms of planning and teaching. Teachers enjoyed the researching and planning of the sdgs within the science topics, but there isn't much out there at the moment, so they had to create new slides and resources. We have two hours of science per week, but that still isn't enough to do justice to the science with a global learning lens. **What additional resources / support do you need to implement the approach more effectively?** Whilst we have done a good job at providing each year groups SDGs to use within their planning, more support to map the SDGs across the year and the programmes of study would be helpful, especially when thinking about the experiments and enquiry we do at the end of each unit.
So What: So what is the importance of this learning? So what more do I need to know about this? So what have I learnt about this? So what was different to what I knew previously?	Considering the priorities of the school is really important Supporting the school with themes may be useful, as well as giving teachers an awareness of the goals, so they can take ownership of making authentic links. This school seemed really empowered by the whole process and were gaining momentum without much support.
Now What: Now what can I do? Now what do I need to do? Now what might I do to improve or enhance the provision / experience / support for teachers in the use of global learning in primary science?	Follow up required.
Additional comments	

Appendix XXVII School A display samples

A Science display sharing a sustainable development goal (School A)



The science display in a Year 4 classroom which outlines the sustainable development goal, climate change.



The display includes the principles which underpin the science teaching and learning across the school. The acronym 'evolving' includes the importance of considering how science is the made relevant to the children's lives, ensuring enquiry skills support 'future citizens'.

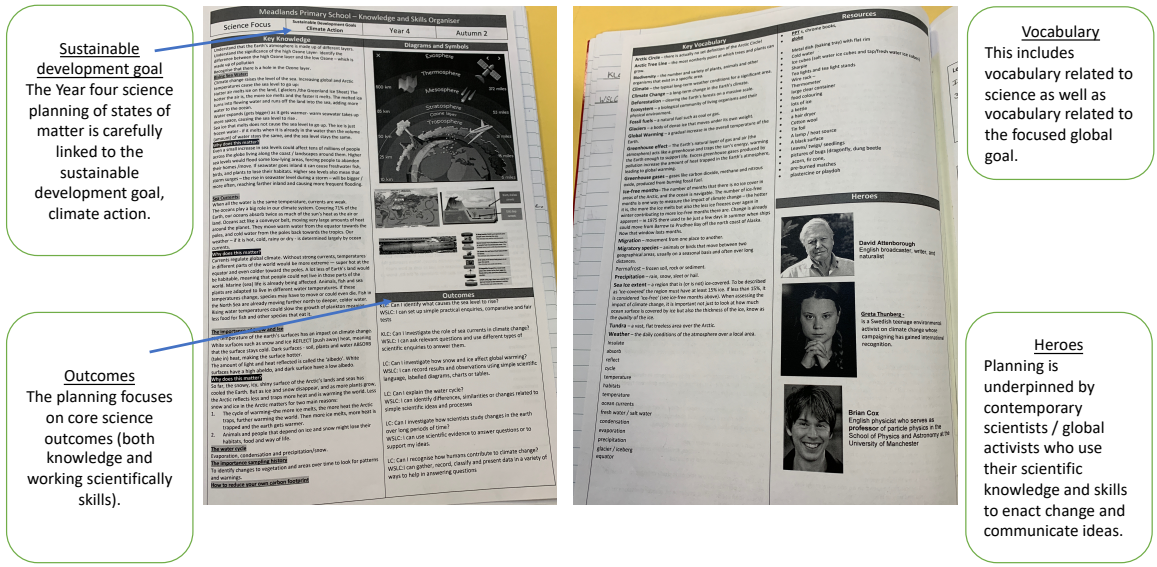
A science display in Year 6, sharing the sustainable development goal 12, responsible consumption.

The display shares children's work on the reduction of food waste.

Although the display includes some of the science behind action, e.g. material recycling, composting, this could be developed further to demonstrate how action is underpinned by core subject knowledge, e.g. what can recycled, how composting works.

Appendix XXVIII An example of a graphic organiser integrating global learning

An example of a Year 4 science planning organizer used by school A



Appendix XXIX An example of a global learning in science week

Summer of STEM – School B

Year group	SDGs	Immersion	Inquiry (Science and maths)	Innovation (Engineering and technology)
1 Plastic Fantastic https://practicalaction.org/plastics-challenge (adapt for younger children)	9 – Innovation 12 – Responsible consumption 14 – life below water	Find out about what things are made from plastics and where plastics come from. Consider how plastics might affect animal habitats.	Investigate which plastics we throw away at home and at school. Consider the useful properties of these plastics.	Create an invention using recycled plastics
2 **Future Fashion** https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-a-spacesuit-k4.html	9 – innovation	Find out what astronauts need in space to survive.	Different groups consider different aspects of the suit – recycling water, materials that protect against the sun	Design your own space suit that enables you to breathe, drink, and protect you from the cold and the sun!
3 – **Floating food** https://practicalaction.org/floatinggardenchallenge	2 – zero hunger	Research and explore how areas prone to flooding still grow their crops and ensure they produce enough food.	Investigate the best floating structures considering materials and shapes.	Design and make a structure that enables farmers to continue to grow their crops even when the land floods.
4 – Wonderful water https://practicalaction.org/water-for-the-world	6 – clean water and sanitation	Find out where water comes from / problems with getting clean water around the world.	Investigate different ways of filtering water using different materials.	Design and build your own water filter
5 – **Windy Wheels** https://practicalaction.org/wind-power-challenge-stem	7 – affordable and clean energy 9 – innovation 13 – climate action	Find out about the different ways energy is generated. Explore different wind turbines around the world and consider why they are used.	Investigate how to make the most effective wind turbine to catch the wind – changing materials, blade shapes, etc.	Design a simple wind turbine capable of lifting a cup off the floor up to bench height
6 **– Stop the spread** https://practicalaction.org/stop-the-spread	3 – good health and wellbeing 6 clean water and sanitation	Researchers in your team should lead on finding out about some of the problems caused by poor hygiene and the importance of hand washing.	Investigate most effective ways to collect water with strong, sustainable materials.	1. Design, build and test a working model that will collect rainwater that can then be used by pupils to wash their hands when in school. 2. Produce education materials on why hand washing is important in preventing the spread of infectious diseases in a format they will and engaging and learn from.

Appendix XXX An example of planning from case study B

Programme of Study	Notes and guidance	Global Learning
All living things Pupils should be taught to: -describe the life cycles common to a variety of animals	All living things Ensure pupils study their local environment throughout the year so that they recognise the stages of growth and reproduction in a variety of living things. Pupils can apply their knowledge and skills by:	DIVERSITY: Developing awareness and respect for plant and animal diversity around the world

including humans (birth, growth, development, reproduction, death), and to a variety of plants (growth, reproduction and death) -describe respiration as the activity that releases energy from food as a fuel to maintain the body's activity, and identify that plants also respire.	-observing, measuring and recording information about plants and animals, including humans, on the life processes involved in growth and development, through e.g. drawings, time lines, life cycles, charts, videos and diagrams. -comparing the life cycles of plants and animals that pupils have studied with other plants and animals around the world (the rainforest, under the oceans, desert areas and prehistoric times). Support this work with a study of the biographies of David Attenborough (naturalist) and Gerald Durrell (behavioural biologist). In Year 6, pupils will be taught more about reproduction.	INTERDEPENDENCE: Conservation of habitats and environments
<u>Animals including humans</u> Pupils should be taught to: -Identify and name the basic parts and organs of the human circulatory and gaseous exchange systems, and explain their functions, including: - human circulatory system - the heart, blood vessels, blood, blood pressure and clotting - gaseous exchange system - lungs, nose, throat, bronchi, bronchial tubes, diaphragm, ribs and breathing.	<u>Animals including humans</u> Ensure pupils continue to learn about the main body parts and internal organs introduced in Year 4 (skeletal, muscular and digestive system, and how they have special functions). They will be introduced to: -circulatory system – made up of the heart and blood vessels that carry blood to and from the heart; blood; blood pressure. -human gaseous exchange system – made up of the lungs and air vessels that carry air to and from the lungs; nose, throat, trachea, bronchi, bronchial tubes, diaphragm, ribs; breathing as the movements that cause exchange of gases between the body and its surroundings. [207] Pupils can apply their knowledge and skills by: -recording information about organs and systems of the human body through e.g. drawings, labels, diagrams, displays, photographs etc. -comparing the organ systems of the human body with the organ systems of a variety of animals, e.g. the human heart has four chambers; the frog's heart has three chambers. Record findings with accuracy and using scientific techniques. This work can be supported by studying the story of William Harvey (described the circulatory system) and Galen's work on dissection.	CITIZENSHIP: Developing an understanding of keeping healthy – balanced diets, making healthy choices. Medical research, understanding the consequences of harmful drugs such as nicotine and alcohol. HUMAN RIGHTS: Communicating awareness of healthy lifestyles for the wider community. Understanding life processes and human needs.
<u>Properties of everyday materials and reversible change</u> Pupils should be taught to: -compare and group together everyday materials based on evidence from comparative tests and fair tests, including hardness, solubility, conductivity and insulation (electricity and heat), behaviour with magnets	<u>Properties of everyday materials and reversible change</u> Ensure pupils continue to practise the names, properties and uses of everyday materials, begun in Key Stage 1. In Year 4, they were taught to classify materials as solids, liquids and gases. Pupils will also be familiar with the ideas of hardness, electricity and magnetism. Reversible changes: dissolving salt in water – salt can be retrieved by evaporating the water; non-dissolvable solids such as sand - can be retrieved from liquid by filtering; ice – can be returned to liquid state of water by melting; solids – can separate flour and sugar by sieving. Ensure that pupils are clear about safety at all times. Pupils can apply their knowledge and skills by: -describing examples of reversible changes from everyday life (in cooking, in fiction and non-fiction books, and from other pupils' test results);	SUSTAINABLE DEVELOPMENT: Awareness of reducing, reusing and recycling of materials – developing awareness and problem-solving relating to packaging and material choices. HUMAN RIGHTS: Relationship between clean water and health – designing water filtration and cleaning systems. SUSTAINABLE DEVELOPMENT: Making sustainable choices related to material use and consumption.

-explain that some substances will dissolve in liquid to form a solution, and how to recover a substance from a solution -use knowledge of solids, liquids and gases to decide how mixtures might be separated, including filtering, sieving and evaporating -give reasons, where appropriate, for the uses of everyday materials based on evidence from comparative tests and fair tests, including metals, wood and plastic -demonstrate that dissolving, mixing and change of state are reversible changes.	-discussing and recording the uses of a variety of materials found in a variety of places (at home, buildings around a town or city, forms of transport). In Year 6, pupils will be taught about changes that are difficult to reverse, and the formation of new materials. In Year 5, pupils should be planning investigations, including recognising and controlling variables where appropriate; for example, a fair test of factors influencing solubility might involve varying mass of sugar and temperature of water to test how these variables influence time taken for sugar to dissolve. They should be taking measurements using a range of scientific equipment, with accuracy and precision; using stopwatches: seconds (s) and minutes (min); using a thermometer: temperature in degrees Celsius (°C); mass in grams (g); and volume in millilitres (ml). They should record their data using e.g. scientific diagrams and labels, tables, bar and pie charts or models, and report their findings, including written explanation of results, causal explanation and conclusions. They should be presenting their reports in written form or as displays or presentations and using their results to make predictions for further tests. Pupils are not required to make quantitative measurements of heat and electrical conductivity at this stage. It is sufficient to demonstrate that some materials will conduct electricity better than others (for example, some conductors will produce a brighter bulb in a circuit than others), and that some materials feel hotter than others when a heat source is placed against them.	

Appendix XXXI Case Study School C – Reflection on in-house professional development

Aim: ***To develop a Global Learning approach to Primary Science across school***

1) Introduction of planning framework to moderate schemes of work:
2) Brainstorming session with all teachers of primary science to see how we can support each other's planning and to discuss the incorporation of the Global Learning approach in science.
3) Bring in the ideas of: Ranking, Critical thinking, UN's SDGs, Philosophy for Children & OSDE into the Science Programmes of Study and Lesson delivery

https://explorify.wellcome.ac.uk/
https://globalprimarysciencecouk.wordpress.com/
https://sustainabledevelopment.un.org/sdgs
https://p4c.com/
https://www.globalprimaryscience.co.uk/osde/

3) The following points of action /suggested developments were noted:

Year 3:
Autumn:
International Space Station (SDG 9: Industry, innovation and infrastructure): this theme underpins learning about digestion, diet and keeping healthy on a space mission.
Rainforest (SDG 15: Life on land) – this theme is underpinned by habitats and endangered species.
Spring:
Clockwork radio and torch (SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable) Using knowledge and understanding of light and sound to develop clockwork radios and torches for communities that do not have consistent access to electricity. Consideration of innovative ways of ensuring communities have access to useful infrastructure.
Summer Term
Magnets and alternative transport around the world (SDG 7: Affordable and clean energy) Consideration of transport around the world which may be better for the environment as well as being beneficial to people and places.

Water (SDG 12: Responsible consumption and prediction) – Using the theme of water to explore states of matter, as well as looking at how to have access to drinking water without using plastic bottles – exploring alternative drinking bottles.

Year 4:
Theme: Accessing clean water around the world (SDG 6 Access to clean water and sanitation) Drawing on knowledge and understanding of states of matter and separating materials to purify water (focusing on enquiry and problem-solving skills), drawing on understanding of why dirty water might not be safe.
Theme: Innovative transport of the future (SDG 9: Industry, innovation and infrastructure and SDG 12) Using understanding of forces to look at streamlined vehicles, reducing drag, use less fuel. Designing own vehicles of the future.
Theme: Space Mission: Following from Colin Stuart talk Mission to Mars. Water on Mars. Exploring why haven't we gone yet and how life would need to be adapted to survive on Mars. Drawing on SGD 3: Good health and well-being and underpinning this with an awareness of what all humanity needs for survival.
Theme: New Materials. (SDG 9: Industry, innovation and infrastructure) What new materials have been invented in the last 5/10 years. Discussing why different countries use different materials and how we are developing new sustainable materials for the future.
Theme: Science of community (SDG 11: Sustainable cities and communities) Drawing on appreciation and knowledge of how different animal groups communicate, instruments of different communities, celebration of difference and interdependence. Non verbal signalling in nature. Male species more colourful than female. Bee dances. Different types of instruments in different cultures. How are the sounds they make different and why? How we can develop communication in the future.

Year 5: 2020/21 move topics around.
Autumn: Circuits and light. Use of solar power. On iPads focus e-learning .co.uk Science Investigations 2 Solar Cell investigation. SDG 7: Clean and affordable energy)
Spring: Circle of Life & Growing up Growing Old. (SDG 2 and 3: Zero hunger and good health and well-being) – developing an understanding of healthy living around the world.

Appendix XXXII A summary of semi-structure interview responses related to global learning in primary science professional learning

	SLT	HOD	A	T	S
How do you think teachers and trainee teachers should be supported to relate their science curriculum to the real world and global issues? In what ways do you think this could be done?	It makes learning more realistic, practical and memorable! More resources, more video clips and more ideas in training of this approach. Integral to what we teach, engaging the children and making science learning interesting and fun. Need to develop more clusters to share ideas, with better links with secondary schools so that our science learning is relevant to what they need in their future studies.	Through science network meetings - teaching the science leads to take it back to their school. Through resources such as GLPS website. Building confidence in the teachers for them to feel like they can adapt the curriculum to today's world by supplying them ideas of how to link (again through resources and training) and apply. An important dimension to making the learning interesting in science.	I enjoy teaching science because of this reason, and believe that it is a real motivating factor to invest time and passion into the subject area. This could be done through celebrating global days, embracing global learning-oriented clubs and initiatives, e.g. eco club The Pod. Global issues / sdgs are integral to the curriculum – thus giving consultants and ITT providers the impetus to equip teachers with the skills to integrate it. Support and understanding of SLT regarding how different it is from other subjects and why teachers need to keep abreast of current advancements in science. The government needs to recognise this, to ensure that there is no	Certainly, a website is a step in the direction, as teachers need to be able to access issues and ideas easily. Twitter would be useful as well as ongoing CPD. I also think that we need free and up-to-date resources that relate the curriculum to current issues. I do. I think publicising more what schools are doing and what it entails would be good. Like pics and info and examples on the whole process. More modelling and awareness of Global learning, strategies and how things can	Yes! More free/low cost workshops or visits from local "scientists" and accessible resources/engaging hooks to teach engaging lessons. Yes, world issues are quite difficult to keep up with. However, having technology, Knowledge of where to access it, newspapers they can subscribe to and social media can be powerfully used Yes - By making science more meaningful to the children they are more likely to take the knowledge away with them and use it By giving programmes of study modern, relatable themes, such as instead of materials, exploring food packaging. Yes! The website is a good start, but lectures/workshops

	Essential and it should be an expectation. It helps children to see the purpose of what they are learning beyond the facts. Clear links by unit of study/ NC objective would be useful This planning model ensures that content and delivery are of a high quality. Continued support both in experts coming in and websites to use with resources I use a scheme to send my teachers on exchanges to countries in Africa to develop their expertise and add a global dimension to their teaching repertoire. Teachers don't have time to go beyond the objectives in the programmes of study	Develop more clusters to share ideas. Make better links with secondary schools so that our science learning is relevant to what they need in their future studies. Need to develop more clusters to share ideas Training needs to be extended to SLT / and even parents. We are currently compiling a list of things related to wider opportunities for our science clubs and weeks It provides a purpose for what is being learned beyond the teacher assessment framework	gap between what needs to happen in school learning to ensure we have the skills for future scientists in our society; Better professional networks to help link schools with real scientists and keep abreast of current developments. Discussion – twitter More awareness of SDGs as a teacher trainer. As I focus on the curriculum framework, I believe that unless they are part of the policy, I suspect any integration will be sporadic and not consistent across schools. Without being part of the curriculum policy, it is difficult to ensure this is done with consistency. Modelling and worked ideas, it can be a useful tool to engage both pupils and teachers. My heart says that this is a great idea, but I worry that There is not enough time to ensure that the teachers have secure knowledge and skills in science to underpin a global approach with links to sustainable development goals. *I don't think it [Global Learning] should be a priority due to the lack of time schools / teachers have.* *Teachers need to appreciate the importance of developing basic knowledge before enabling children to relate it to the real world*	be incorporated into an already squeezed curriculum. Perhaps some support to use more social media / news to support awareness and integration. Yes, I think the curriculum needs to be adapted to suit current affairs, e.g global warming and new inventions By having external science advisors (e.g. Stem ambassadors) come to school.	would be a great way of achieving this. Yes definitely. Particularly with regard to climate change. It would also be brilliant to have access to resources that can link science learning to the real world, such as more educational videos that explain difficult concept in real life and ideas of how children can carry out experiments and collect data in the real world.
If at all, what resources / platforms could be used to support a Global Learning in Primary Science approach?	Twitter x 2 Leadership magazines Word of mouth Face to face discussion Collaboration to share good practice to develop the quality of what we teach. National STEM website Science lead who has an excellent bank of knowledge and resources to support the curriculum and beyond.	Reach out reporter website – to discuss and keep abreast of science related news around the world (informs both teachers and children) ASE conference ideas and stands with GL ideas Explorify and other resources to develop critical thinking British science week (current focus 'our diverse planet for 2020) Practical action	Practical action Water explorers Leicester borough has an eco-education coordinator, encouraging all local schools to get their green flags. School embraces a range of national initiatives including being a fair-trade school, doing fair trade fortnight Fairtrade Eco-club Practical action	BBC news General news. Facebook. Social media CBBC newsround and journal articles Facebook newsfeeds. E.g.: io9 Variety of websites about making.	The STEM website, Twitter, Instagram and BBC news Social media – bite-sized articles and videos Explorify Guardian- news Wellcome Trust

	Specialised science teacher designation. Links and collaboration with Institute of education	Tag videos, reach out reporter and Standing on the shoulders of giants.			
In what other ways do you think trainee teachers and qualified teachers could be supported to deliver a science curriculum truly fit for purpose?	Training needs to be secure especially for those who have less of a passion for science Teachers need more practical activities that mirror real science and this should be done during teacher training. Inset, lectures at the PCP SCiTT, direct links to the website. We need to ensure our teachers and trainees are up to date and confident with current science and developments. Through the support of a specialised science teacher in the school to ensure teachers are kept abreast of new initiatives and developments. Confidence with linking SDGS and science National Curriculum subject knowledge	Training in how to develop the curriculum to fit their school. Working alongside schools to create 'science curriculum leads' who can then support other schools. trainee teachers having specific science training on how to adapt lessons so they can bring that knowledge with them to their new roles. I agree that teachers and students need to develop a better understanding of the SDGs in order to incorporate them into their teaching. I think this is part of my role as a head of science. I will definitely try to support my team with this.	Global learning needs to underpin the principles of science in the school to ensure teachers embed it. If children are exposed to global learning in lots of ways, e.g. assemblies and clubs, teachers are more likely to embrace global learning in science. Find ways of educating the teachers as well as the students. Use PSQM to allow a school to invest in embedding global learning into the science curriculum The value of educating the head teacher, and ensuring that leadership supports / believes in investing in global learning, even when it is not an accountability measure. Encourage teachers to be more confident in teaching science and creating fun and meaningful lessons and investigations to support learning. Face to face training, modelling activities to ensure teachers become confident. More modelling of effective lessons which bring pedagogical strategies and creative ideas together. Ideas modelled and trialled, translated into lessons to support teachers to deliver them with confidence, support engagement and interesting lessons. The SDGs need to be translated into an educational framework with guidance on what they could mean for the teacher. Not fixed but needs to provide guidance to support them to see where it can be embedded into the curriculum. A framework on which to hang the curriculum on, and should provide a contextual to bring the curriculum to life.	More government initiatives to put more focus and importance on science within the primary curriculum Not necessarily testing, but greater accountability, yes. Good recommended resources would be great. It feels like the BBC makes less educational content now than in the past. So recommendations for good videos and interactive tools so you feel like you are working towards something beyond testing. Just lots of (free!) resources like (some, not all) of the ASE examples. Just good examples of classes that have had big successes sharing best practice. The uses of schemes of work, resources and support from specialist science teachers would ensure a rich science curriculum with real life application	Less objective/achievement based lesson planning! The objective of science teaching and learning should be assessed based on a varied diet of dialogue and interaction in and out of the classroom, not simply being able to “name and identify” or “write up results” etc. Motivated to add more of a global dimension if it was in the teacher standards and a bigger emphasis of lesson planning rather than achieving the outcomes / success criteria. Global online platform for sharing resources with different dimensions, e.g. an instrument from your country, a traditional meal, etc. Network to share all ideas, using a mixture of media. Encourage teachers to be more confident in teaching science and creating fun and meaningful lessons and investigations to support learning. More modelling of effective lessons which bring pedagogical strategies and creative ideas together. Support on how to keep up to date with global issues and current affairs, e.g. who to follow on twitter More ideas about how to realistically develop skills of working scientifically- A global learning perspective which is still practical / enquiry based.

Appendix XXXIII A table suggesting ways global learning in primary science could be supported

Semi-structured interview responses to question:

'How do you think teachers and trainee teachers should be supported to relate their science curriculum to the real world and global issues?'

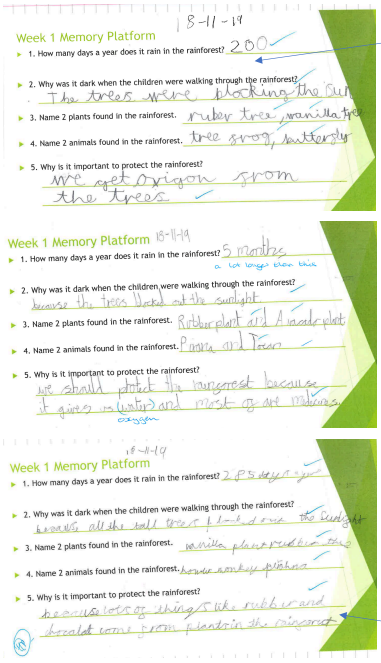
Stakeholder	View / Attitude	Summary
SLT	It makes learning more realistic, practical and memorable. (SLT 1) Integral to what we teach, engaging the children and making science learning interesting and fun (SLT 2). Essential and it should be an expectation (SLT 3). It helps children to see the purpose of what they are learning beyond the facts (SLT 4).	SLT support a curriculum which has relevance and purpose.
HOD	An important dimension to making the learning interesting in science (HOD 1). It provides a purpose for what is being learned beyond the teacher assessment framework (HOD 2).	HOD all identify the importance of developing the purpose of science.
Advisor	I enjoy teaching science because of this reason, and believe that it is a real motivating factor to invest time and passion into the subject area (A1). Global issues / SDGs need to be integral to the curriculum – thus giving consultants and ITT providers the impetus to equip teachers with the skills to integrate it A2).	Interesting identification of importance of linking it to curriculum to support teacher educators to integrate it.
Teacher	They do.It brings curriculum to life (T1) Yes, I think the curriculum needs to be adapted to suit current affairs, e.g global warming and new inventions. It will be useful to develop the application of learning (T2) Yes (T3)	All agree that they need to be supported
Pre-service teacher	Yes! (S1) Yes, world issues are quite difficult to keep up with. Yes - By making science more meaningful to the children they are more likely to take the knowledge away with them and use it Yes! Yes definitely, I don't know much about global issues. Particularly with regard to climate change.	All identified the need for support with knowledge and understanding of global issues

Appendix XXXIV 'In what ways do you think this could be done?'

Stakeholder	*Suggested Support*	*Summary*
SLT	More resources, more video clips and more ideas in training of this approach (SLT 1) Need to develop more clusters to share ideas, with better links with secondary schools so that our science learning is relevant to what they need in their future studies (SLT 2). Clear links by unit of study/ NC objective would be useful (SLT3) Planning model to ensure that content and delivery are of a high quality (SLT 4) Continued support both in experts / advisers coming in and websites to use with resources (SLT 4) Exchanges to countries in Africa to develop their expertise and add a global dimension to their teaching repertoire (SLT 5)	SLT identify the need for clear support in the form of resources, clear links to programmes of study and a planning framework. They also identify the need for support from 'experts' or advisors, suggestive of some top-down structure.
HOD	Through science network meetings - teaching the science leads to take it back to their school (HOD 1) Through resources such as GLPS website (HOD 2) Building confidence in the teachers for them to feel like they can adapt the curriculum to today's world by supplying them ideas of how to link (again through resources and training) and apply (HOD 3) Develop more clusters to share ideas (HOD 3). We need to make better links with our feeder schools so that our science learning is relevant to what they need in their future studies (HOD 4). I think training needs to be extended to our SLT / and even parents (HOD 4). We are currently compiling a list of things related to wider opportunities for our science clubs and weeks (HOD 5)	Three out of five HODs identified the need of support from other clusters / networks to share ideas. HODs also shared importance of supporting teachers and SLT to identify links between science and global issues – a clear consensus of training and support requirements and a community of practice.

	Need to develop more clusters to share ideas (HOD 5)	
Advisor	Teachers need to be made more aware of celebrating global days, embracing global learning-oriented clubs and initiatives, e.g. eco club The Pod (A1). Global issues / SDGs need to be integral to the curriculum – thus giving consultants and ITT providers the impetus to equip teachers with the skills to integrate it (A2). Support and understanding of SLT regarding how different it is from other subjects and why teachers need to keep abreast of current advancements in science (A2). The government needs to recognise this, to ensure that there is no gap between what needs to happen in school learning to ensure we have the skills for future scientists in our society (A3); Better professional networks to help link schools with real scientists and keep abreast of current developments (A3). Discussion – twitter More awareness of SDGs as a teacher trainer. As I focus on the curriculum framework, I believe that unless they are part of the policy, I suspect any integration will be sporadic and not consistent across schools (A4). Without being part of the curriculum policy, it is difficult to ensure this is done with consistency. Modelling and worked ideas, it can be a useful tool to engage both pupils and teachers (A4). I think teachers need to understand the importance of cognitive load, so that they really appreciate the importance of developing basic knowledge before enabling children to relate it to their own lives, to problems, the real world or to think critically about ideas. (T4) There is not enough time to ensure that the teachers have secure knowledge and skills in science to underpin a global approach with links to sustainable development goals (A5).	Advisors clearly identified the need for a top-down structure to support the integration of SDGs / Global Learning in policy and curriculum to ensure a motivate and support teachers to implement it. They also identified that advisers themselves needed a greater awareness of SDGs and global issues.
Teacher	Certainly, a website is a step in the direction, as teachers need to be able to access issues and ideas easily. Twitter would be useful as well as ongoing CPD (T1). I also think that we need free and up-to-date resources that relate the curriculum to current issues (T2) I think publicising more what schools are doing and what it entails would be good. Like pics and info and examples on the whole process. More modelling and awareness of Global learning, strategies and how things can be incorporated into an already squeezed curriculum. Perhaps some support to use more social media / news to support awareness and integration (T3). By having external science advisors (e.g. Stem ambassadors) come to school.	Teachers identified the need for more resources and support to integrate a global learning approach to primary science.
Pre-service teacher	More free/low cost workshops or visits from local “scientists” and accessible resources/engaging hooks to teach engaging lessons. However, having technology, Knowledge of where to access it, newspapers they can subscribe to and social media can be powerfully used By giving programmes of study modern, relatable themes, such as instead of materials, exploring food packaging. The website is a good start, but lectures/workshops would be a great way of achieving this. It would also be brilliant to have access to resources that can link science learning to the real world, such as more educational videos that explain difficult concept in real life and ideas of how children can carry out experiments and collect data in the real world.	Pre-service teachers identified the need for more resources, websites and guidance (similar to the teachers).

Appendix XXXV Samples of work from School C

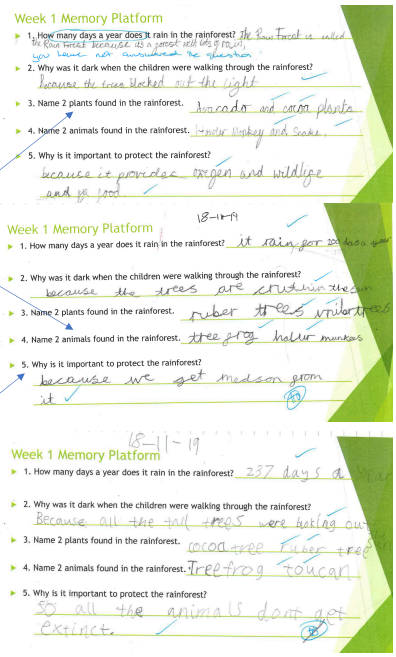


Good use of resources (video clips of rainforests in different countries)

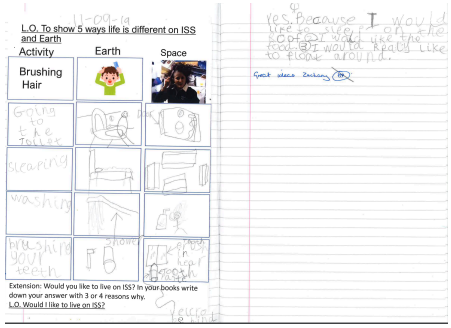
Clear underpinning science (light and shadows, identifying plants and animals)

Critical thinking: Teacher used questions which enabled children to appreciate and protect the rainforests.

Responses demonstrate independent thinking and celebrates a wide range of ideas (which teacher fed back to children, celebrating different perspectives).



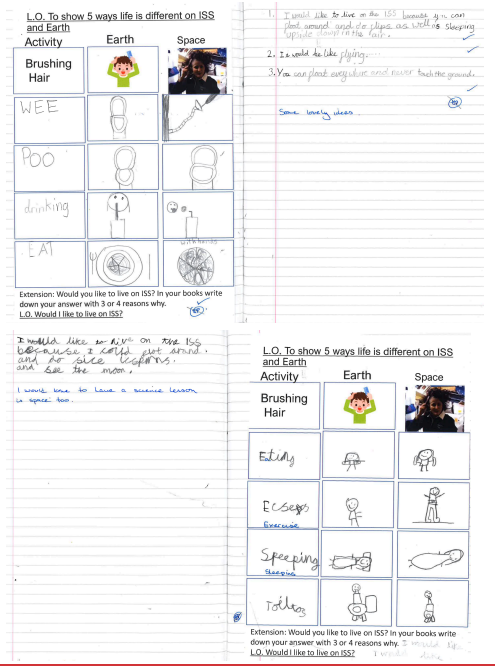
Evidence of planning related to SDG 9: Industry, innovation and infrastructure.



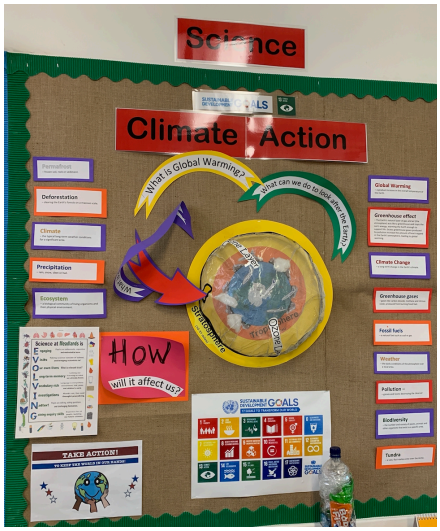
The teacher aimed to use critical thinking by asking the children to compare life on Earth and in space and ask them to give reasons for why they would like to live on the International Space Station.

Again, sharing different ideas helped the children appreciate different reasons and perspectives.

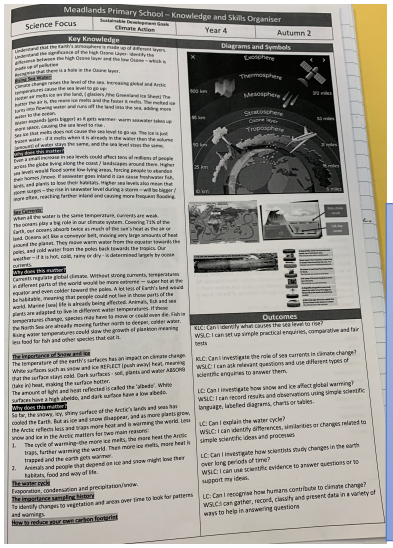
The children went on to explore what people do on the International Space Station (SDG 9).



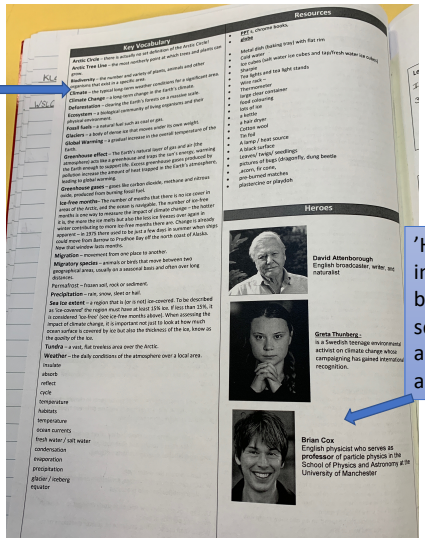
XXXVI School A Global learning science displays



XXXVII School A Global learning science planning



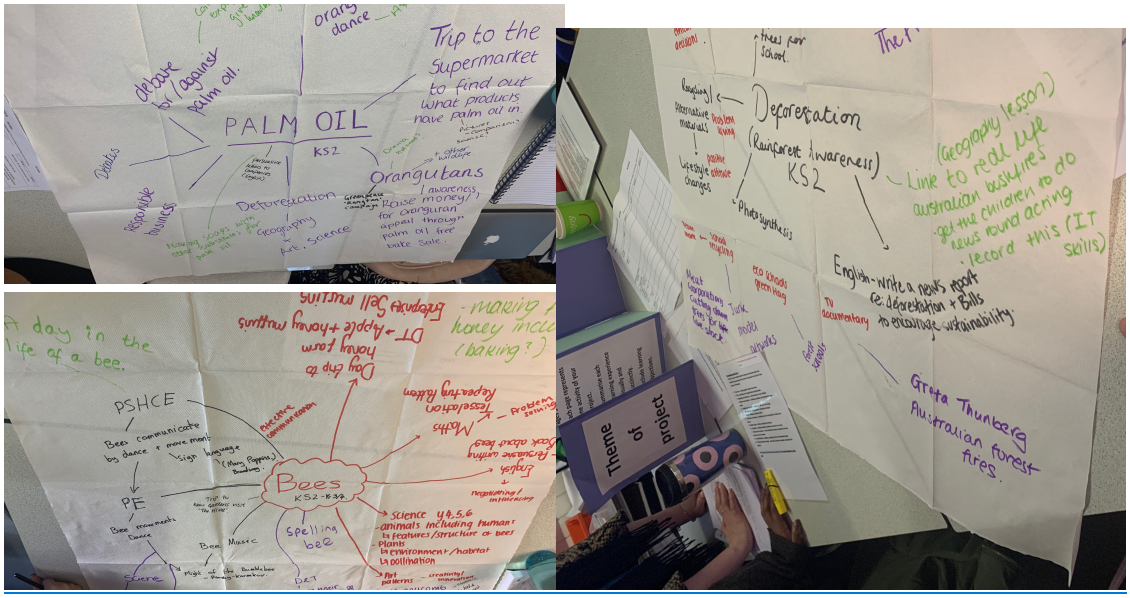
Key vocabulary includes both science and global issues related words.



Learning outcomes include:
KLC (Key learning concepts) which related to global issues;
WSLC (Working scientifically learning concepts) which relate to the science curriculum skills;
LC(Learning concepts) which relate to the National Curriculum science programmes of study.

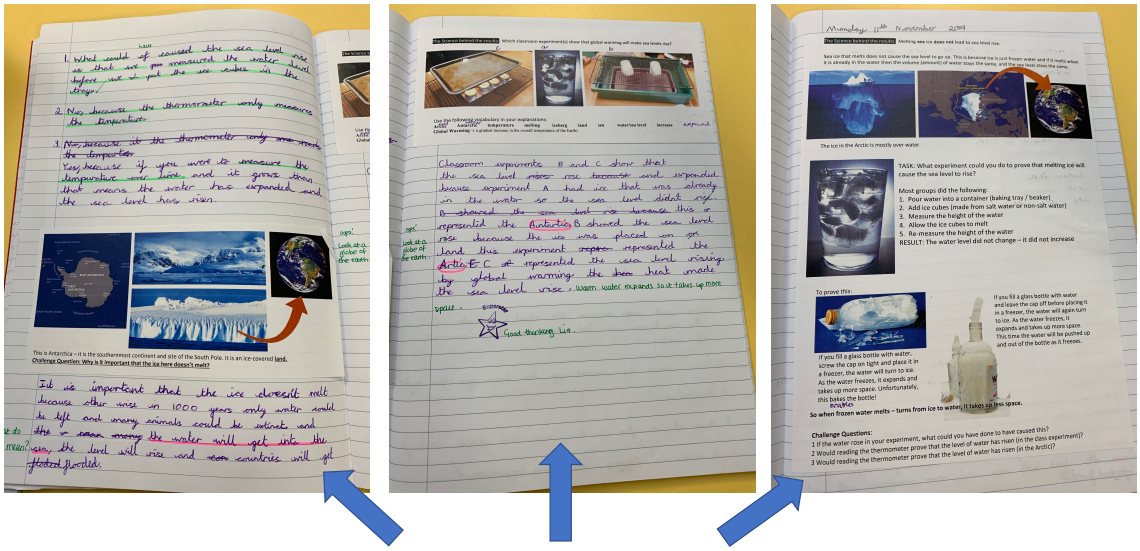
'Heroes include both scientists and global activists'

XXXIII School C Initial planning ideas session



XXXIV School A Example of children's work

School A: Year 4 science experiment to demonstrate the impact of global warming on sea levels.



Clear development of working scientifically skills and awareness of global issues.