How do we teach a knowledge rich primary science curriculum in an exciting way?

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A Research & Development Project

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How do we teach a knowledge rich primary science curriculum in an exciting way?

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Abstract

Research has shown that fewer pupils are choosing to pursue science in the later years of their education. One key reason for this is that pupils' attitudes towards learning science become more negative. Debate exists about when this reported decline occurs, but some suggest that pupils' attitudes to science begin to change towards the end of their primary education. One way to counteract this may be through teaching exciting lessons that are rich in scientific knowledge. This study interviewed year 5/6 pupils (ages 9-11), surveyed primary school teachers and conducted an intervention lesson series, which pupils were surveyed on, to explore ways of making knowledge rich science lessons exciting for pupils. Three task types were investigated during the intervention lesson series: talk tasks, inquiry-based learning and drama. The findings showed that all three task types made science lessons exciting for the pupils but to differing degrees, with drama tasks proving especially effective. This study also found that practical activities were highly important to both pupils and teachers for making science learning exciting, although it highlighted potential issues surrounding the effectiveness of how practical activities are used in science lessons. Issues surrounding the teaching of science such as time, space, resources and topics, were also raised and explored. The findings have impacted the future approach to science at the setting school.

Chapter 1: Introduction

1.1 Focus of research project and school context

This research project explored ways of teaching a knowledge rich primary school science curriculum, in ways that most excited pupils. The interest in investigating this topic was influenced by both my findings and readings during my practitioner research, conducted during Part 2 of the MLT, and a situation that had arisen in my school setting.

The practitioner research conducted during Part 2 of the MLT explored how using talk tasks in primary science lessons was an effective way of motivating prior higher attaining pupils and drew similar conclusions to that of published literature (Braund and Leigh, 2013; Wall, 2002). Throughout the research, and upon completion, I wondered what other effective ways of teaching primary science might be that most excited and engaged pupils. I had read about several methods during my Part 2 research, but unfortunately the scale and time frame of the Part 2 assignment did not allow me to explore more of these at the time. It did however provide me with the foundations for a larger project to undertake in Part 3.

During my Part 2 project, a second issue presented itself that linked to the topic that I was researching. I am the science coordinator at my school - a state primary in Buckinghamshire. The school is a one and a half form entry school which means pupils are taught in mixed year groups. A result of this is that the curriculum for most subjects, including science which is the focus of this study, are taught on a two-year rolling basis. Partly due to the complexities this presents and due to an increased focus on staff wellbeing from SLT, subject leads were encouraged to investigate purchasing schemes that comprised of premade lesson plans and resources.

As science lead, I wanted to find a primary science scheme that could be taught across all year groups and would ensure progression and full curriculum coverage. After looking into many schemes, finding one that provided the 'invaluable knowledge' that Ofsted indicated they will look for in their newest inspection framework (Ofsted, 2019), but at the same time seemed like it would be exciting for pupils proved difficult. Having explored issues around pupil motivation in primary science during Part 2, I personally felt strongly that having an exciting, engaging and hands-on science curriculum, throughout primary school, is paramount to pupils' success and interest in the subject. This type of curriculum has been shown to then greatly-benefit not only pupils' attainment in the subject but also the longevity by which they pursue science (Ainley and Ainley, 2011; Fokides & Papoutsi, 2020). Global research has identified a decline in pupils who pursue science in later education and the worry is that there will be societal repercussions from this (OECD, 2006; Porter and Parvin, 2008; Smith, 2011). Due to the decline in the pursuit of science education, there is a drive to improve pupils' attitudes towards science and this is a sentiment that, as a keen scientist myself, I very much share.

I was cautious about using a pre-prepared scheme of work that is highly exciting, but completely ignores teaching pupils the knowledge and facts that are fundamental to science. Therefore, I concluded that establishing a balance between imparting key knowledge, whilst also teaching exciting lessons that positively impacted pupils' attitudes towards science, was important.

The aim of this project was therefore to investigate how we as a school can teach a knowledge rich primary science curriculum, in an exciting way for pupils. With this knowledge I felt that I would be in a stronger position to decide what type of scheme we should invest in, or if it may be better that we create and follow our own path. Obviously if we chose to do the latter, which before the research began would have been my personal preference, it would have implications for teacher workload, but I would be able to present this idea to SLT supported by research and literature on the possible benefits it may have for pupils' learning and progress in science.

In terms of education in general, I think the issue described above is a problem that many primary schools face. Since the Ofsted framework changed (Ofsted, 2019) schools are now thinking about how they achieve full curriculum coverage. Purchasing pre-made schemes are a relatively simple way of achieving this. I would therefore suggest that I am probably not alone in having trouble finding one that is adequate. As my school is part of a liaison group, there will hopefully be a chance for me to share my findings with other science leads in partner schools.

Chapter 2: Review of Literature

2.1 Preliminary questions to explore in review of literature

To investigate the issue described in chapter one a literature review was undertaken with the aim of exploring two main questions and sub-questions:

- What makes a knowledge rich curriculum?
  - What is the theory and importance of a curriculum being knowledge rich?
  - What are the implications of the theories for teaching science?
- Is an exciting primary science curriculum important?
  - What are pupils' attitudes towards science?
  - What are effective methods to teach an exciting science curriculum?

2.2 What is a knowledge rich curriculum?

What teachers should teach and the knowledge they should impart to their pupils has long been a hotly debated topic, not just in academia, but also in schools and governments around the globe (Cuthbert and Standish, 2021). One main cause of contention is whether it is best to lean towards teaching a curriculum focused on 'skills', or alternatively one that aims to provide pupils with knowledge that allows them to understand key concepts in subjects (Corbell, 2014). Whichever side of the debate one falls, it would be remiss of someone involved in UK education to not acknowledge the trend towards a knowledge focused curriculum. The newest iteration of the National Curriculum for England (Department for Education, 2014) has a greater focus on key knowledge and fact learning than previous editions and HM Chief Inspector Amanda

Speilman, the head of Ofsted, personally endorses a curriculum that is ‘focusing on a rich foundation of knowledge’ (Speilman, 2017). Similarly, Ofsted’s newest inspection framework has a strong focus on knowledge in the curriculum and they are clear on, what their recent research has called, the ‘invaluable knowledge’ they want pupils to learn and for subject leaders to ensure it is in their school’s curriculum (Ofsted, 2019).

The idea of ‘invaluable knowledge’ is no doubt linked to others’ thinkings regarding the term ‘powerful knowledge’. Powerful knowledge is a concept that aims to pinpoint what type of knowledge should be included in curriculums and was coined by Young (2009) with the purpose of re-establishing the importance of knowledge in curriculums. Powerful knowledge stems from work conducted in social realism and is the idea that power exists in education as knowledge (Alderson, 2020). Therefore, for a society and education system to be fair and just, it should be the case that all pupils have access to, and indeed are entitled to, be taught the knowledge that will allow them to have equal opportunities in later life (Gericke, Hudson, Olin-Scheller & Stolare, 2018). Powerful knowledge is not the same as general knowledge or common sense but is specialised in both how it is produced and subsequently how it is passed from one person to the next (Young, 2013). This may be one reason why many argue for the inclusion of powerful knowledge in curriculums as it would otherwise be hard to obtain by pupils in their general day to day lives. Most would agree that a good curriculum should build upon the experiences that pupils learn in their everyday lives (Reiss, 2017) and this is perhaps what powerful knowledge aims to do. Calls for curriculums richer in powerful knowledge stem from what some, especially Young (2013), believe to be a current ‘crisis’ in curriculum theory.

There are several criticisms of the theory of powerful knowledge. The first is that the idea of what powerful knowledge is could be misinterpreted, which may lead to a curriculum content that is inappropriate. Reiss and White (2014) make the argument that many primary school children are taught about forces and what happens when forces are not in balance, however this is a concept that many physics graduates cannot consistently apply. Powerful knowledge may lead to pupils learning things that are not relevant, interesting or even understandable. As these factors have been generally said to be important for pupil engagement (Bruner, 1960; Hayes, 2003), this could lead to decreased engagement.

Another criticism is that knowledge cannot be powerful without a consideration towards who the knower is and what their circumstances are (Reiss, 2017). This also brings into question Young's idea that 'everyday concepts' are limiting. One pupil's day to day will vary greatly from the next and what one person needs to know compared to another might be very different. Therefore, it has been argued that some pupils are not in fact held back by their 'everyday concepts' as is suggested by Young (White, 2018).

When it comes to ideas of knowledge and curriculum arguably one of the most influential voices in education is that of Hirsch. Over his career Hirsch has argued that pupils should all be taught the same knowledge, a curriculum based upon hard facts. Hirsch argues for something that he calls 'Core Knowledge' (Hirsch, 2016). The theory of this is that all pupils should be taught set facts over the course of their education to provide them with a cultural literacy (Hirsch, Kett and Trefil, 1987). With this core knowledge stored, Hirsch argues, that it will allow all pupils no matter their cultural capital or background knowledge to operate as good citizens in the country they live.

Hirsch has stated that this in his opinion is where schools have failed in the past as they have taught curriculums that are disconnected and based on educational theories that do not work (Hirsch, 2006).

The second of Hirsch's ideas is that pupils should be taught this core knowledge in a sequential way. This means that pupils should be helped towards slowly assimilating the core information over several years and schooling should be about building upon what has been learnt before. The purpose behind providing pupils with a relatively small amount of new content is so that they are not bombarded and can master what they are being taught. Those who argue for this style of curriculum would say this means only introducing subjects at certain ages so that they are not too difficult to comprehend, which is in line with Piaget's theory of cognitive development (1936). Others however, such as Bruner (1960), would say that any child can understand any topic, so long as it is broken down for them in the correct way. This idea of progression and sequencing through the years can now easily be seen in the National Curriculum (Department for Education, 2014) and has also become a key area for Ofsted inspections (Ofsted, 2019).

The ideas of Hirsch have certainly had an influence on the curriculum in the UK. In 2015, Schools Minister Nick Gibb stated,

'*No single writer has influenced my thinking on education more than E. D. Hirsch.'*

Likewise, many of the statements made in a speech given in 2009 by the then Education Secretary, Michael Gove, to the RSA can be easily linked to Hirsch. Gove even talked about, *'a common stock of knowledge on which we can all draw and trade,'*

One of the main criticisms of Hirsch's work is that the approach he suggests schools should take, only leads to the continuation of existing power structures (Gordon, 2018; Woodhouse, 1989; Yandell, 2017). That is that pupils are taught a body of knowledge that is white, elitist and excludes any other cultures or heritages. Therefore, how can we really be teaching pupils societal core knowledge when the knowledge only relates to a small proportion of society (Yandell, 2017). Many also find issues with the idea that there is a large core of knowledge that should be taught to all students as realistically only some knowledge is needed by certain individuals (Reiss, 2017). The second of these criticisms is similar to criticism of Young's powerful knowledge and perhaps brings into question whether there is a degree of naivety when suggesting there is knowledge that everyone needs to know.

In summary, there has been a noticeable shift towards a knowledge rich curriculum in recent years. This has been heavily influenced by Young (2009) and Hirsch (2016). A knowledge rich curriculum is about providing learners with information that might not be obtained in daily life yet is crucial to their success. It should be taught in a sequenced way to build upon prior learning. The next section will focus on what makes a science curriculum knowledge rich.

2.3 What are the implications for teaching a knowledge rich science curriculum?

What therefore is a knowledge rich science curriculum? Scientific understanding can be broken down into two parts; knowledge and reasoning (Bybee, 1997; Koerber *et al.*, 2015).

Knowledge concerns the scientific concepts and theories that help explain processes or outcomes that might be observed. Arguably science as a subject is already knowledge rich, as pupils are learning scientific facts, ideas and concepts that they would be unlikely to learn in their everyday lives (Yates and Millar, 2016). There is realistically more that could be done to ensure knowledge richness. One of the key issues historically with science curriculums is that pupils may have viewed the curriculum as just a bombardment of unconnected facts (Budiansky, 2001; Liu, Lee and Linn, 2010). The key then is about creating a sequenced curriculum that is coherent and builds upon previous learning whilst filling in any gaps (Sikorski & Hammer, 2017). Since the introduction of the latest iteration of the national curriculum in England (Department for Education, 2014), the sequencing of curriculums and ensuring that knowledge progression occurs, whilst gaps are filled, is something that has been of great focus for primary schools.

The second part of scientific understanding, reasoning, is essentially about the process of scientific enquiry, which includes generating hypotheses and experimental procedures (Zimmerman, 2007). These could also be thought of as core skills which are arguably as essential to science learning as subject knowledge. Tolmie, Ghazali and Morris (2016) list three core skills: accurate observation, reasoning about causal connections and applying knowledge. Anderson and Clarke (2012) argue that science teachers need two kinds of knowledge to teach science: knowledge of science (substantive) and knowledge about science (syntactic).

It appears then that in science education the two types of knowledge, substantive and syntactic, are both important for scientific understanding. By the very nature of the subject, science is knowledge rich but within the subject this 'knowledge' relates to both facts and theories as well as scientific processes.

The next section of this literature review will explore how a knowledge rich science curriculum, both in terms of knowledge and reasoning, can be taught in a way that engages pupils. Theories as to why this is important and methods by which it may be achieved, will also be presented.

2.4 Is an exciting primary science curriculum important?

Defining what makes learning exciting can be difficult but some suggest that it is something that brings immediate rewards and might produce a 'wow' factor in learners (Moore, 2003). In this study, the term "exciting" is used to mean the cause of great enthusiasm and eagerness towards learning in science. This definition was applied to this study as the focus was about teaching an exciting curriculum for pupils.

An exciting curriculum is arguably an effective way to ensure pupils enjoy a subject or topic. Research has shown that teaching pupils in a way that excites, stimulates and maintains a sense of fun can foster a positive relationship with a subject and this can have several benefits, including increased academic achievement (Ainley and Ainley, 2011; Fokides & Papoutsi, 2020). It has also been said that individuals learn better when they feel strong positive emotions (Dulay & Burt, 1977; Krashen, 1982) whereas negative emotions reduce an individual’s focus and therefore impede learning (Fredrickson, 2001). Excitement is surely one of the strongest positive emotions and experiencing this emotion during knowledge rich lessons may help towards achieving maximum learning potential, as Dewey (1933) said that learning conditions are at their optimum when an activity is both playful and serious.

The need to ensure that pupils feel positively about science has been well documented in recent years in the UK, as pupils in the later years of their education are deciding not to pursue science subjects (OECD, 2006; Porter and Parvin, 2008; Smith, 2011). This trend can also be seen globally (Convert, 2005; Haas, 2005). The result of this is a fear that not enough individuals will pursue science careers and fill the roles that society will require in the future. Although there does appear to be a general agreement within the academic community that pupils’ attitudes towards science have been and still are declining, some research argues that this is not the case. DeWitt, Archer and Osborne (2014) conducted a longitudinal study in England and found that of the 5600 primary school pupils they surveyed in Year 6 (10 years old), by Year 8 (12-13 years old) most of them still enjoyed science. Although this seems positive, other research indicates that it is a year later, at age 14, pupils start to turn away from science (Ashbacher, Li and Roth, 2010; The Royal Society, 2006) and it is the final year of primary school that the decline begins (Murphy and Beggs, 2005). Possible reasons for the decline in pupils’ attitudes towards science will now be presented.

2.5 Pupils' attitudes to science

The reasons as to why some pupils' attitudes towards science decline as they get older are many and some of the ideas, that are most relevant to this study, will now be presented. Palmer, Burke and Abusson (2017) found it easier to split the factors that may influence pupils into two categories: extrinsic (the pupils themselves) and intrinsic (environment and outside influences). For clarity I shall do the same.

2.5.1 Pupils' ability and self-efficacy

One intrinsic factor is pupils' ability and self-efficacy. It is widely accepted that when individuals are good at something (in this case academic success in a subject) they are going to find more enjoyment and interest in it (Brown and Lent, 2006; Postlethwaite and Haggarty, 2010). Bandura (2006) wrote about how our abilities influence our choices, therefore in terms of science education it could be that those who deem themselves 'good' at science are the ones that pursue it further as they find more enjoyment out of it. Many pupils find science a difficult subject (Kearney, 2016; Lyons and Quinn, 2010; Patall *et al*., 2018) and the level of challenge involved may reduce enjoyment over time. This might lead to pupils' attitudes towards science declining as they mature and better understand their own abilities in relation to others. Some hold an alternative view that as pupils get older, they view science as being too easy and this causes enthusiasm to wane (Pell and Jarvis, 2001). I would argue that this is unlikely to be the case as due to the vastness and complexities of science, it is surely perceived by pupils to be a tougher subject (Potvin and Hasni, 2014).

2.5.2 Impact of enjoyment of a subject

Another intrinsic factor is interest, engagement and enjoyment. Ainley and Ainley (2011) found that the degree to which pupils enjoy their science learning was closely linked to how interested and engaged they were, with their definition of enjoyment being the personal value of science and the interest in learning science. Delivering curriculums in a way that pupils find interesting and enjoyable is something that many teachers strive for day to day. However, despite teachers' best efforts, boredom is an emotion that most pupils encounter on possibly a daily basis and is probably omnipresent within educational settings across the world. Older studies found that pupils experienced boredom for up to 32% of the day (Larson and Richards, 1991). The fact that this study was conducted almost thirty years ago might suggest the results are not relevant today as surely pedagogy and curriculum has adapted to counteract this issue, but more recent studies have identified similar issues. Daschmann, Goetz and Stupnisky (2011) found that 44.3% of pupils frequently reported feeling bored in math lessons, how this translates to other subjects is not particularly clear but even a 10% decrease is still a high percentage.

Undoubtedly, the task of trying to keep a young person engaged throughout a school day is challenging, but the reasons for trying to do so are important as boredom has been linked, via both empirical and theoretical approaches, with negatively impacting motivation, learning and achievement (Pekrun, 2006; Goetz, Pekrun, Hall and Haag, 2006). Similarly, Putwain *et al*. (2018) looked at the relationship between enjoyment and achievement with year 5/6 pupils across 25 state primary schools. They found that higher enjoyment and lower boredom resulted in greater academic achievement and that higher boredom and lower enjoyment led to reduced academic success. Several other studies support these findings and have shown positive correlations between academic achievement and enjoyment, whilst boredom negatively correlates with the same (Ahmed *et al*., 2013; Daniels *et al*., 2009; Putwain, Sander and Larkin, 2013). One could argue that other emotions must surely be at play in the participants of all these studies and therefore academic success cannot be purely consigned to boredom or enjoyment levels. None the less, the fact many studies have drawn similar conclusions means that the importance of keeping pupils interested, engaged and enjoying their lessons, even if for purely academic reasons, should not be understated.

Boredom has been associated with lack of challenge, dated and repetitive teaching techniques and teachers' attitudes (Frenzel, 2010). Specifically aiming to reduce boredom, by having an exciting curriculum, is arguably a way to keep pupils engaged and motivated about their learning, which is important for developing positive attitudes towards a subject (Landis and Reschly, 2013; Slavit, Nelson and Lesseig, 2016).

Finally, Palmer, Burke and Aubusson (2017) found that students classed their expectation of finding a subject enjoyable and interesting as the main influence on their decision making, when deciding on a subject. As student choice plays a key part in whether they decide to pursue a subject in the long term, it seems that planning and delivering an exciting and engaging curriculum is a method to ensure more pupils will stay interested in studying science for longer.

The literature on this topic has led me to conclude that ensuring pupils are as interested and engaged in their science lessons as possible is a keyway to ensure that they enjoy the subject, make good progress and in the future will want to continue studying it. One way of doing this could be through exciting lessons.

2.5.3 Gender

Although the role of gender will not be specifically explored within this study, research has shown that it is an intrinsic factor that determines pupils' attitudes towards science. Literature tends to agree that generally girls not only have a less positive attitude towards science than boys, but also have lower self-efficacy in science (Barmby, Kind and Jones, 2008; Regan and Dewitt, 2015). Barmby, Kind and Jones (2008) also found that the rate at which girls' attitudes to science declined in the early years of secondary school was more pronounced than that of their male peers. A study conducted in the United States found that boys attitudes declined faster than girls (George, 2006), however these findings appear to be relatively unique.

2.5.4 Curriculum quality

An extrinsic factor that may play a large part in influencing pupils' attitudes towards science is teaching and curriculum quality (Palmer, Burke and Aubusson, 2017). For many pupils, school science lessons may be one of the only opportunities where they are exposed to the variety of topics that make up the UK science curriculum. Admittedly, pupils are likely to encounter subject content from topics such as 'Animals including humans' and 'Living things and their habitats' (year 5) in their daily lives due to the popularity and accessibility of the topic. Television programmes, family discussions and outings to places such as zoos may mean that, for some pupils, these topics form a part of their socio-cultural backgrounds (Vygotsky, 1978). However, when it comes to topics like 'Light' or 'Electricity' (year 6) pupils are surely less likely to encounter and understand the key concepts of these outside of school.

Topics arguably play a role in engaging pupils with science as they have been shown to create strong relations between a pupil's interest in a specific topic and their overall enjoyment and emotional engagement with science (Ainley & Ainley, 2011; Fredricks, Blumenfeld and Paris, 2004). Plant science is taught at multiple phases throughout both primary and secondary education in the UK. However, a general low pupil interest in learning about plants has been recorded, this has been dubbed 'plant blindness' (Schussler and Olzak, 2008). This in turn often leads to pupils having a low level of understanding and many misconceptions regarding the science of plants (Stagg and Verde, 2019). Interestingly, Reeve *et al*., (2004) found that the complexity of a topic had little impact on pupil engagement and the role of the teacher, considering pupils' needs and interests when planning was much more important. This will be explored further later.

School science may be the main, and for some the only, occasion where pupils are exposed to the breadth of science topics. It is of fundamental importance that curriculums are exciting and interesting to pupils to foster in them a passion for the subject.

Whether most curriculums achieve this is contested. The National Curriculum in England for primary science (Department for Education, 2014) states that,

"pupils should develop a sense of excitement and curiosity about natural phenomena,"

However, many argue that most science curriculums do not achieve this ambition. Some academics say that science curriculums are too heavily focused on the learning of facts from a wide range of topics (Duschl, Schweingruber and Shouse, 2007). It should be recognised that sometimes fact learning is necessary and especially with a subject such as science, there is sometimes little room for opinion. A curriculum designed heavily on fact learning is surely not going to be that exciting or engaging for pupils and if that is their only experience of the subject week on week, over time their interest in the subject could wane. Science is one of few subjects that allows for a more hands-on approach and this benefits many pupils by turning theory into concrete. Kopp and McCormack (2015) go as far as to state that pupils cannot learn science unless they do science.

2.5.5 Teaching

Global research has consistently shown that primary school teachers are generally falling short when it comes to the teaching of science, both in their pedagogy and attitudes towards the subject. The main reasons highlighted by the literature are to do with teacher confidence, competence and personal attitudes towards the subject (Smith, 2014). The literature is clear when it comes to the importance of having an enthusiastic teacher with a positive attitude towards a subject, to engage pupils (Appleton, 2003; Harlen and Holroyd, 1997; Murphy, Beggs and Russell, 2005).

It is often the case that primary school teachers end up teaching subjects for which their knowledge may not be as extensive as it should be (Newton and Newton, 2001). The content of a science curriculum is seen as complex by many primary school teachers (Anderson and Clark, 2011) and the result of this, is that scientific facts and knowledge are not always taught effectively, resulting in misconceptions being passed onto the pupils from the teacher (Jarvis and Pell, 2004; Parker; 2004). The fact some primary teachers' subject knowledge may be lacking also impacts their confidence when teaching science. Research from Australia showed that many trainees who entered the profession had existing negative attitudes towards science which may be linked to their own school experiences (Gilbert, 2013; Tytler, 2007). With the UK school system being comparable to Australia it is perhaps unsurprising that the UK has experienced similar issues. Sharp, Hopkin and Lewthwaite (2011) proposed that perhaps no other area of the UK curriculum has seen such a push to improve teaching quality in the last thirty or so years as science. However, even with this attention it remains difficult to the generalist teacher, that is more often found in a primary education setting, and attitudes towards the subject remain negative.

A teacher who has low self-confidence in a subject may try to avoid creating lessons that could push them far out of their comfort zone (Harlen and Holroyd, 1997; Newton and Newton, 2011). This in turn makes the learning boring and stagnant for pupils who over time possibly become disenfranchised with the subject. As the quality of teaching in science is said to play an important role in how engaged pupils are (Tytler and Osborne, 2012), the general evidence of sub-par and bland teaching in primary schools may be a reason for the evidenced decline of pupils' attitudes towards the subject at the end of primary school.

Another factor that may contribute towards primary teachers having a more negative attitude towards science is its reduced importance in the national curriculum over recent years (Ofsted, 2013; Serrett *et al.*, 2016). Since 2009, there is no longer an end of Key Stage Two test in science and the Wellcome Trust (2014) has evidence that the time and emphasis dedicated to science in primary schools has declined. Blackmore, Howard and Kington (2018) say that in recent years the status of science as a subject within the UK primary curriculum has greatly reduced. Even if teachers may not necessarily feel negative towards science, they may view other parts of the curriculum (reading, writing and maths) as more important, which may be replicated by pupils. This influencing of emotions has been called the emotional contagion theory (Hatfield, Cacioppo & Rapson, 1993) and it has been found that people are more likely to mimic the emotions of trusted individuals (Howard and Gengler, 2001), one example of which could be pupils mimicking their teachers.

More generally schools may be placing less importance on science which undoubtedly will affect pupils' attitudes. Research carried out by the Wellcome Trust CFE Research (2017) found that only 57% of school leaders ranked science as 'very important'. When this is compared to the 83% for English and 84% for mathematics it indicates a stark contrast. There is also evidence that the lower importance placed on science has led to funding pressures and subsequently access to equipment. Research shows that primary teachers report having access to only 46% of the equipment that is needed to teach practical science effectively and the average UK primary school spends merely £2.89 per pupil annually on science resources (SCORE, 2013). These findings may indicate that the value placed on science within the primary curriculum is another integral factor as to why pupils' attitudes towards the subject are declining.

2.6 Summary

This section has presented research showing some of the reasons why pupils may decide against pursuing science and why their attitudes towards it may become increasingly negative. The literature review highlighted curriculum, teaching and engagement as some of the main reasons why pupils may not enjoy science. This led me to consider how an exciting curriculum may be an effective method of teaching a knowledge rich primary science curriculum. The next section will explore possible methods for teaching an exciting, knowledge rich science curriculum.

2.7 What might be some effective methods of teaching an exciting science curriculum?

Reasons for having an exciting science curriculum have just been presented and discussed. The next section of this chapter will review and critique, some of, the literature around possible methods of delivering an exciting curriculum, in primary schools.

2.7.1 Inquiry based science learning

When people think of learning science, experiments and practicals are closely associated. They are also important to pupils as research has shown that although pupils attitudes towards science decline, their attitudes towards practical work in science does not (Barmby, Kind & Jones, 2008). Many cases of historical research have asked children to complete the Draw-a-Scientist Test. These usually demonstrate that children picture scientists as older/middle-aged men, with wild hair, glasses and a lab coat, who are generally carrying out a dangerous or ‘exciting’ experiment (Chambers, 1983; Koren and Bar, 2009; Newton and Newton, 1998). This shared cultural image of 'science' is no doubt one reason why people think of science and experiments together, but at a fundamental level science is about inquiry. Science is defined by the Oxford English Dictionary (Oxford University Press, n.d.) as,

'the intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment.'

The very definition of the word is about practical activity, experiments and observations. This leads some to conclude that learning science is about doing, above all else. Therefore, inquiry-based learning in science is important.

Inquiry-based learning encompasses several methods that aim to get pupils actively involved in their learning. This can be through questioning, exploring new understanding, discovering and testing new discoveries (Lemlech, 2009). Inquiry based learning is not to be confused with confirmation-level inquires - where a teacher would demonstrate and pupils simply observe, listen and discuss. Although some would argue that this style of teaching has benefits, the level to which pupils are engaged and excited when they are observing and listening is surely lower than when they can do something for themselves, which is the focus of inquiry-based learning.

Inquiry-based learning comes in two forms: guided and open inquiry (Kopp and McCormack, 2015). These two forms of inquiry-based learning have similarities which leads to some viewing them as the same. However, there is a main difference that makes the methods very different approaches to teaching. During a guided inquiry the teacher will pose a question and the pupils will then investigate this, through whatever means they see most fit. An open inquiry goes a step further by challenging pupils to create their own question, plan how best to investigate and finally carry out the investigation. The teacher's role during an open inquiry is to guide the pupils' thinking.

Both these forms of inquiry-based learning have benefits and flaws, but neither should be thought of as better than the other. Some shared problems of inquiry-based learning, that may be the reason why some teachers choose not to use this approach for teaching science, are as follows. Firstly, inquiry-based learning is time consuming and often requires ample classroom resources (Kopp and McCormack, 2015). It can be seen of as chaotic as all pupils are doing different activities which may require varying levels of support and equipment. This also links with a final issue, which is that some teachers may lack the confidence to facilitate such activities.

Arguably, the benefits of inquiry-based learning outweigh the negatives. Many say that inquiry-based science learning is the best method for teaching science (Brown, 2017; Crawford, 2014) while others go as far to say that it is the basis of primary science education, or at least should be (Bybee *et al*., 2006; Spencer and Walker, 2011). The benefits are said to include increasing pupils' motivation, aid construction of meaning and the acquisition of knowledge, develop higher order thinking skills and finally give learning relevance as pupils can work as actual scientists do (Alake-Tuenter *et al.*, 2012; Crawford, 2014; Kopp and McCormack, 2015). These benefits and past experiences of inquiry-based learning make me believe that it is certainly a method worth exploring in this study.

2.7.2 Drama and theatre for science

A second approach that may be an exciting way to teach pupils science is through drama and theatre. Historically, science and the arts have seen very little cross over between the two disciplines and traditional forms of pedagogy have dominated the science classroom (Abrahams and Braund, 2012). However, more recently it has been suggested that drama may be an effective pedagogical tool for the teacher of science.

Using drama as a method for teaching is not a new idea and the Theatre in Education movement of the 1960s is one such example (Jackson, 2002). With science having generally been taught in more traditional manners it perhaps took longer for drama to filter into the science classroom, but some were starting to suggest its pedagogical benefits (Duveen and Solomon, 1994; Gardner, 1991; Kentish, 1995). Kentish (1995) stated one of its possible benefits as providing personal engagement and later research formed similar conclusions as to how drama in science teaching can increase pupil enthusiasm and engagement and lead to greater creativity (Abed, 2016; Ødegaard, 2003).

In terms of benefits to learning the literature is mixed. Some have reached conclusions that drama itself does not benefit learning, in terms of increasing factual knowledge, but it does aid a pupils' ability to explain concepts and apply them (Metcalfe *et al.*, 1984). Another benefit, not linked to greater knowledge, is that drama stimulates conversation among pupils (Dorion, 2009). This could be part of the reason why pupils are then able to explain themselves better, but there is little literature that evidences this. I would argue that in science the skill of explaining and applying scientific concepts is as important as factual knowledge and furthermore, surely if one can explain a scientific concept, that is demonstrating factual knowledge. There is research that supports my thoughts which shows that drama can lead to direct benefits for learning. Several studies have linked drama or theatrical activity to an increase in pupils' factual knowledge (Bailey and Watson, 1998; Peleg and Baram-Tsabari, 2011; Stagg and Verde, 2019). Stagg and Verde (2019) found that the knowledge pupils gained was not just immediate but long-term. Year 5 and 6 pupils watched a performance by two actors about plant reproduction and their subject knowledge was tested before and afterwards. The pre- and post-tests showed a significant difference in subject knowledge regarding plant reproduction but interestingly when they were tested once more, several weeks later, their subject knowledge was still good. Arguably, for most of these studies, there are a great number of different variables involved which may also lead to increased subject knowledge and it would perhaps be rash to assign all the credit to drama. However, Bailey and Watson (1998) challenge this assertion in their own study. Although they accept that the scientific rigour of their methodology could be criticised, due to the lack of being able to perfectly control the investigation, the significant difference shown between pre- and post- test results is important and may be indicative of just how useful a tool drama may be for teaching pupils in a way that both excites and imparts knowledge.

One final benefit of drama for science, which is especially important for this study, is that it makes learning science fun and exciting for pupils. Stagg (2020) recently researched using immersive drama to help pupils, between the ages of 10 and 11, learn about the life and work of Carl Linnaeus. After the session 94% of pupil participants said that they enjoyed it, while 74% said that they preferred it to their usual science lessons. Some of the reasons cited were about it being a more ‘hands-on’ approach. This also shows that it may be a useful method to make topics that pupils’ usually find relatively dull more interesting. Linking to what was said about ‘plant blindness’ in section 2.5.2

of this dissertation, Stagg and Verde (2019) found the use of drama effective at enthusing pupils about plant science.

Jackson and Leahy (2005) also drew similar conclusions when pupils attended museum drama sessions. This is perhaps unsurprising as for various reasons science teaching in the UK primary classroom does often follow a didactic approach, therefore pupils enjoy the novelty of out-of-classroom approaches (DeWitt and Storksdieck, 2008). Nonetheless, any activity that positively motivates pupils and gets them excited about their science learning is surely beneficial.

2.7.3 Talk tasks

The final method of teaching an exciting science curriculum for pupils, that shall be presented in this study, is the use of dialogic teaching and in particular talk tasks.

Dialogic teaching, and the benefits for pupils, has been a focus of much academic research since Vygotsky first put forward his views that talk is important for allowing individuals to construct and deepen their thoughts and understanding (Vygotsky, 1978). Although his theories have been criticised by some for not considering the degree to which different cultures place importance on talk (Rogoff, 1990), it is widely accepted that talk plays an important role within the classroom and such literature as the Bullock report (Bullock and Department of Education and Science, 1975) and the National Oracy Project (Norman, 1992) have highlighted talks importance within UK education.

The use of talk to benefit learning has been relatively widely researched – a search on the British Education Index for literature associated with the words ‘talk’ returned 2,438 results with the vast majority of these being relevant when abstracts were skim read. Interestingly, using talk as a form of engaging pupils is much less researched with a search on the same database for the words ‘talk’ and ‘engagement’ returning only 110 results, of which only a handful were relevant. When the search parameters were then further narrowed to the focus of this study by including the word ‘exciting’, there was only one result. Arguably, this shows that how talk tasks are used within science education is an area that is lacking research, but the existing work on the topic raises interesting points.

A positive relationship between the use of talk-tasks in primary science lessons and pupils’ attitudes towards science may exist. Studies have shown that talk and group discussions can be an enjoyable way for pupils to learn (Braund, 2009; Howe *et al.,* 2007; Thurston *et* al., 2010). Other studies have found that the use of talk in science teaching can help build positive personal dispositions and identities towards science (Mercer, Dawes & Staarman, 2009). Braund and Leigh (2013) found that as the frequency of science talk activities increased in 24 primary schools in the UK, pupils’ self-efficacy around science talk also increased. Both factors also then positively correlated with pupils having an improved attitude towards science. This undoubtedly shows a potential benefit of talk tasks, but something to highlight is that all the teachers involved in this study had undergone some form of training in delivering and facilitating talk-tasks. For talk tasks to have the greatest impact they need to be guided by someone who has the correct expertise and knowledge to guide them (Baines, Blatchford and Chowne, 2007; Bee Tin, 2003). Although the teachers in Braund and Leigh’s study had the required skills it seems unlikely that this is the case nationwide, as studies have shown a lack of effective dialogue in UK primary classrooms (Alexander, 2008). Therefore, whether the results of this study would be similar in all settings is questionable, but during Part 2 of the MLT I undertook research within the topic and found similar results.

Practitioner research I conducted found that prior higher attaining pupils in years 5 and 6 enjoyed participating in talk tasks and the pupils reported finding them exciting and interesting (Blakeley, 2020). Pupils who took part in the task appeared to be engaged, motivated and afterwards explicitly said how much fun they had exploring and challenging their own ideas. Admittedly, there were several limitations to this study, with the main one being that only one talk task was able to take place as the Coronavirus pandemic forced schools nationwide to close. This therefore raises the question that perhaps the pupils only enjoyed the task so much as it was a novelty, which would instinctively raise their interest levels anyway (Deci, 1992). Due to the small scale of the study, only prior higher attaining pupils were involved meaning that the views of other ability pupils might have been different to those reported.

Having reviewed literature, the potential benefits of talk tasks seem to outweigh the criticisms and they are certainly a useful pedagogical method. Their ability to excite pupils will be specifically explored in this study.

2.8 Conclusions from review of literature and research questions

The review of the literature led to several conclusions. Firstly, there is debate regarding what a knowledge rich curriculum consists of, but science may be a subject where knowledge is easier to teach, as pupils should be taught the most current scientific fact. The key to doing this is through sequencing and knowledge progression. This is something that I would argue is done well in my setting, therefore my concerns regarding knowledge richness lessened.

The literature review made clear the need for an exciting and engaging science curriculum for pupils. The reasons for this are many and several have been presented. One factor that stood out was the impact of curriculum and teaching quality on pupils' attitudes. Due to this, some methods that are considered effective ways of delivering exciting and informative lessons were reviewed. Inquiry-based learning, talk tasks and drama for science all seemed to be potentially successful methods for teaching primary science, in an exciting way for pupils. The conclusions drawn from this literature review have shaped several research questions and sub-questions which are presented below.

2.8.1 Research questions

- What do pupils find exciting about science at school?
    - What do they like currently?
    - Is there anything they would like to try or do more of?
- What are the views of colleagues on teaching an exciting, knowledge rich science curriculum?
    - How confident are they in terms of subject knowledge?
    - What do they think are exciting ways of teaching science?
    - What are the difficulties when it comes to teaching science?
- In what ways do different task/activity types compare when it comes to teaching an exciting, knowledge rich science curriculum?
    - What are the pupils' opinions on different task/activity types that could be used for science teaching?
    - How effective are different methods for pupil progression and teaching of knowledge?

These research questions were explored as practitioner research over the course of two school terms in my setting. The methodology used to investigate these research questions is presented in the next chapter.

Chapter 3: Methodology

The practitioner research undertaken in this study was designed to explore ways of making a primary science curriculum exciting for all pupils. Practitioner research in education is defined by Menter *et al*., (2016) as,

'systematic enquiry in an educational setting carried out by someone working in that setting, the outcomes of which are shared with other practitioners.'

This definition fits the scope of what was undertaken in this study as I investigated an enquiry within my setting school, with the aim of sharing the findings with colleagues, to improve our school. This study also fell under the concept of action research. It has been said that the term 'action research' is used too broadly and therefore inaccurately (McAteer, 2013), but as this study consisted of an intervention with the effects assessed to refine future action alongside reflection and evolving action, this study would fall within the scope defined by literature (Menter *et al*., 2016; McAteer, 2013; Whitehead & McNiff 2006).

Several phases of research took place. Firstly, year 5/6 pupils of a mixture of prior attainment levels participated in a semi-structured focus group interview with me. They were interviewed to determine pupils' views on learning science and what tasks/activities they found most exciting. Secondly, teachers in my setting were surveyed to find out their views on what makes an exciting science curriculum and their confidence levels for teaching science at primary level. Finally, a series of nine intervention lessons surveyed year 5/6 pupils' views on different tasks and activities, that the previous two phases and literature had identified as being exciting ways of teaching science. Three different methods were investigated, and knowledge rich lessons were planned with these tasks as the focus. Pupils were surveyed post lesson concerning their opinions. Data collected from these methods was then analysed and used to draw conclusions. How this was done will be explained later in this chapter.

Although the task types that were investigated could be used in lessons across all primary year groups, this research took place with only year 5/6 pupils. There were two reasons for this. The first was this year group is where I teach and therefore it is simple for me to access the pupils. Due to the Coronavirus pandemic the school, where the research took place, was split into bubbles to reduce mixing. As the year 5/6 pupils and I were all in the same bubble it meant that I did not have to worry about crossing bubbles, which could have been difficult logistically. Secondly, I felt that it would have been unfair of me to ask colleagues in other year groups to undertake the extra workload of more planning and if I had tried to help them with this, the workload would have been unsustainable for myself, which could have impacted on the research.

This study aimed for scientific rigor and reliability by having a strict application of scientific method to ensure an unbiased reporting of results.

3.1 Semi-structured focus group interview with year 5/6 pupils

The first part of the research was a semi-structured focus group interview with a group of six pupils from year 5/6. The aim of the group interview was to gather data on pupils' views about their science learning, particularly what they found most and least exciting. A group interview worked well for this as it enabled pupils to interact with each other and encouraged them to develop their thoughts and challenge each other's ideas, whilst allowing a range of views to be heard (Hajar, 2018). It also had the additional benefit of not being too time consuming (Houssart and Evens, 2011). It was anticipated that not all the pupils would understand the questions, or their role in the interview, first time and therefore things would need to be reworded and clarified for some. The adaptability of a face-to-face interview allowed for this, but also gave me the chance to clarify participants answers, which is important as it means insightful data is not lost (Lee Abbott and McKinney, 2013).

A group of six pupils were chosen as this number is regarded as roughly the optimum size for group interviews involving children as there are not too many participants that the interview becomes chaotic, but at the same time there are enough peers that pupils are put at ease and answer freely (Lewis, 1992). The pupils, from year 5/6, were chosen randomly with the use of a random name generator, available through a reward system called Class Dojo. Although it was random, the setting school has Additionally Resourced Provision for 12 pupils, who have Autistic Spectrum Disorder or Social Communication Difficulties and an Educational Health Care Plan. Four of these pupils were in year 5/6 and I felt that their inclusion in the interview group would be unnecessary stress for them. Therefore, I decided to exclude any pupils that had an ARP place if their names were generated. The first six names generated were chosen to participate. They had the option to opt out and this will be discussed in the ethics section later in this chapter.

Due to Covid-19 restrictions, these pupils had to be from my year group for me to sit in the same room as them during the interview. Evidence indicates that focus group interviews are best when participants do not know each other (Cohen, Manion and Morrison, 2018) however, interview situations are also unfamiliar to many children and it is best to make participants feel relaxed and comfortable (Leeson, 2014; Morrison, 2013). Being with peers is a way to counteract existing power relations (Huser, 2010) and sitting in a group, with an adult they knew, was a familiar situation for the pupils. These points, combined with the restrictions due to Covid-19, meant that the decision was taken to interview pupils as a group of peers.

Over 30 minutes, the pupils were posed several questions (Appendix A) to discuss. These questions had been pre-prepared by me, but they were used mainly as conversation starters if the discussion deviated or waned. There was no expectation that all the questions on the schedule had to be addressed in the time. Where possible, the aim was to allow the pupils' answers and thoughts to lead the direction of discussion. For a couple of questions, visual prompts were used to spark discussion. Pupils were shown images of different types of activities that could be undertaken in science lessons (Appendix B) and were encouraged to verbalise their thoughts and opinions. The images selected had been chosen by me based partly of findings in the literature review and other common classroom task types. This is known as the projection technique as no direct question was asked. A benefit of this technique is that it avoids biased answers that may come from how a question is asked (Hurworth, 2012; Leeson, 2014). This tried to mitigate the pupils from answering in a way that they would think desirable to the interviewer.

Whilst the pupils were talking, notes were recorded by me, on general themes and interesting points.

3.2 Teacher survey

The second part of the research was surveying teachers, who were my colleagues, in the form of an online questionnaire (Appendix C). The purpose of this was to discover what teachers across different years groups thought about science learning in school. This included teachers' opinions on pupils' attitudes towards science, what they thought made for an exciting curriculum and their confidence in teaching science, which the literature review had highlighted as a key factor in influencing pupils' attitudes towards the subject. The responses to these questions would then feed into the intervention lessons series phase of the research, in particular the planning of different tasks for the pupils to undertake.

Teachers were emailed a link and asked to complete the questionnaire on Microsoft Forms, which is a part of Microsoft Outlook for Business. Answers provided were then collated on this same software. The questionnaire was a mixture of closed questions, predominately in the form of rating scales, and open-ended questions. The questionnaire comprised of only six questions as it is considered best to keep questionnaires short, to the point and only cover topics to which the researcher wants answers (Cohen, Manion and Morrison, 2018). The rating scale questions would be considered Likert scales as they provided a range of responses to a given questions. As a similar approach was taken to surveying pupils during the intervention phase of the research, the reasons for choosing Likert scales as a method of questioning will be presented later in this chapter.

3.3 Intervention lessons (pupil surveys – Likert scale)

The final stage of data collection involved surveying pupils on how exciting they found science lessons. Data that had been collected from the pupil focus group interview and teacher questionnaires, in addition to findings from the literature review, informed the planning of a series of science lessons, that were taught in year 5/6. The purpose of this was to compare different approaches to teaching knowledge rich science lessons. Specifically, how exciting pupils found different tasks and how pupils' attitudes changed depending on task types.

Three task types were chosen to be compared: drama tasks, inquiry tasks and talk tasks. Nine knowledge rich lessons were prepared which covered the topics of 'Light' and 'Living things and their habitats'. Of these nine lessons, each task type was the main task for pupils to complete in three lessons. Table 1 shows the topic that was taught, the specific learning objective statement and the task type that was implemented. It also shows the dates the lessons were taught, which group and how many pupils contributed to the data. This will be explained in more detail later in this section.

Table 1: Topics and objectives taught to pupils in Year 5/6, for each of the lessons that made up the nine lesson intervention series.			
Topic taught and date	**Learning objective statement**	**Task type**	**Group taught to (number of pupils)**
Light (25/11/21)	I can understand that light is made up of many different colours.	Talk	Whole class (27 pupils)
Light (02/12/20)	I can explain why shadows form the same shape as the object that casts them.	Drama	Whole class (27 pupils)
Living things and their habitats (20/01/21)	I can understand what microorganisms are and why they are useful.	Inquiry-based learning	Key worker and vulnerable children (15 pupils)
Living things and their habitats (26/01/21)	I can begin to classify plants.	Talk	Key worker and vulnerable children (16 pupils)
Living things and their habitats (10/02/21)	I can explore dichotomous keys.	Inquiry-based learning	Key worker and vulnerable children (9 pupils)
Living things and their habitats (24/02/21)	I can describe how plants reproduce.	Drama	Key worker and vulnerable children (21 pupils)
Living things and their habitats (03/03/21)	I can explain how plants reproduce asexually.	Talk	Key worker and vulnerable children (22 pupils)
Living things and their habitats (17/03/21)	I can describe the life cycles of animals.	Drama	Whole class (27 pupils)
Living things and their habitats (10/03/21)	I can describe the process of sexual reproduction in animals.	Inquiry-based learning	Whole class (26 pupils)

Each task type was tested over three lesson to try and mitigate for the fact that the topic of every independent lesson may influence the pupils' views.

At the end of each lesson, pupils were surveyed on how exciting they found the lesson, their overall enjoyment, their views on the task and finally how well they understood the learning objective. To collect this data, pupils were handed a short questionnaire which had a series of closed questions in the format of Likert scales (Appendix D). They then had to read the five statements and rank their opinion on how much they agreed with the statement, with one being strongly disagree and five being strongly agree. Most pupils had Likert scales labelled with number and text, which is said to be a more reliable way of gathering data when using Likert scales (Champagne, 2014; Krosnick and Presser, 2010), however a few SEN pupils had Likert scales differentiated with smiley faces instead to make it more accessible for them. The intention being that their opinions were recorded as accurately as possible.

Due to previously mentioned Covid-19 bubbles, data collected in this format before January 2021 took place in only my year 5/6 class, which compromised of 30 pupils (aged 9-11) of both genders. This accounted for two lessons of data collection. From January 2021 until March 2021, the school switched to remote learning for most pupils. Several factors meant that pupils at home could no longer participate in the data collection, however, some children of key workers and vulnerable children still attended school. This number varied weekly but on average, roughly 17 pupils were being taught in year 5/6. The original intention had been for all three teachers in the year group to teach the lessons to their whole class and then survey their pupils. Teachers would have then fed back their opinions from each lesson to me. However, the small number of pupils that were in school meant that only one science lesson was required each week. These lessons were taught by me and all year 5/6 pupils, who were in school, completed the post lesson questionnaires.

The demographic of this group was different to that of a standard class in the setting. For example, of the 17 or so pupils, over a third were SEN - with a number of those having EHCPs. This situation accounted for six lessons of data collection. For the final two lessons of data collection, all pupils had returned to school and once again my year 5/6 class of 30 pupils (when no absences) participated and provided data. Table 1 shows which group were taught which lessons.

3.4 Why Likert scales?

For both the teacher questionnaire and the pupils' post lesson questionnaires, Likert scales were used as a method of collecting data. This was because they are a widely used rating scale, which indicate frequencies and correlations, but also provide flexibility in responses (Cohen, Manion and Morrison, 2018). They are a fast way of collecting large volumes of data reliably, which was important in this study for several reasons. Firstly, questionnaires completed by pupils were being answered at the end of lessons and therefore time was usually limited to a couple of minutes, so as not to impact on their other learning. Secondly, for the teacher questionnaire I was conscious of teachers' workloads and time. Finally, I was aware that the longer and more arduous the questionnaire appeared, the less likely participants would complete it fully and diligently. Research shows that having too long a questionnaire or putting too much demand on participants can lead to poor quality responses or participant fatigue (Champagne, 2014; Denscombe, 2014). Due to the ease and speed at which Likert scales can be completed, they were an appropriate method of data collection to ensure both quantity and accuracy of data.

Likert scales have limitations. One being that peoples' interpretation of numbers can be different, for example one persons' 4/5 may be a 3/5 for someone else (Friedman and Amoo, 1999). This is an issue that may be even more so applicable when participants are young children. Assigning written labels to each number on the scale is seen as an effective way to counteract this limitation and therefore in this study, all Likert scales had numbers and written labels to help with ranking. An additional benefit of written labels is that they are also better for reliability of data (Champagne, 2014; Krosnick and Presser, 2010).

3.5 Collaboration

I collaborated with colleagues in three different ways. Firstly, colleagues mainly in my year group, but also from across the school, assisted with planning and implementing the series of intervention lessons. An example of this would be a colleague helping me decide on a theme and method for delivering a drama focussed lesson, then teaching the lesson I had planned and providing me feedback before I taught the lesson myself and surveyed the pupils.

Secondly, all teachers in the school completed the teacher survey, providing data to address research question two. Responses to this survey also contributed to determining the teaching approaches that were used in the intervention lessons. All teachers within the school completed the survey providing a range of responses, with the underlying theory that having varied interests would add complexity (Yu, 2011).

Finally, colleagues from my year group dedicated a team meeting to assist me with analysing the data collected from the nine intervention lessons. Cohen, Manion and Morrison (2018) suggest that collaborators can enrich data analysis as they bring their own expertise. It also allowed third parties to see the data and check for alternative interpretations to that of my own or challenge my assertions. From the raw data I was able to prepare several graphs, which were then shown to my colleagues. Questions I had prepared along with their thoughts, queries and conclusions formed a professional dialogue. This raised several points that were included in the discussion section of this dissertation but have also impacted how science will be taught and approached at our school in the future.

3.6 Analysis of data

The data collected from the pupil group interview and the teacher surveys were analysed. Trends or interesting points were looked for and suggestions arising from these, along with literature, determined the three task types that formed the intervention part of this study as action research cycles.

Data from the intervention lesson series was collated on a Microsoft Excel spreadsheet. Pupils' responses to surveys, that took place at the end of lessons, were used to calculate mean values and standard deviations for each of the four statements participants were posed. Four line-graphs were created using Microsoft Excel. Line graphs were chosen as they are useful for showing trends and are accessible and comprehensible to readers (Cohen, Manion and Morrison, 2018). These plotted and compared the data for each of the four statements, that pupils were presented in the post lesson surveys, from the three task types. Colleagues were presented these graphs and the corresponding standard deviations. The professional dialogue the data prompted and colleagues' interpretations of the data, were used alongside mine to steer sections of the discussion chapter of this study.

3.7 Ethical considerations

This study was run in adherence to the ethical guidelines as set out by BERA (2018) and all participants of research were treated with an ethic of respect. CUREC approval was sought and approved for by the University of Oxford (Appendix E).

Adult participants were asked to consent for any data collected from them to be included in the study. To ensure that they were giving informed consent an information section was attached to the top of the questionnaire that explained what the data was for, who would have access to it and how it would be used. A similar approach was taken when data was collected from pupils. The headteacher had provided consent on behalf of the pupils, but they were also handed a participant information sheet that explained to them the process they were involved in. This was read through and explained by me to try and ensure informed consent. Pupils then had an opportunity to ask questions for clarification. It was explained to pupils at this point that although they could not opt out of any changes I make to my practice, it was ok for them to say no to providing answers to survey questions and the pupils who were involved in the semi-structured focus group interview could opt out of the interview at any time. BERA (2018: 2) recommends that participants are aware of the guidelines that are being followed. The process described in this paragraph was a way of doing so in this study.

Consideration was given during this study to the active power relations that may exist and how best to counteract these. Even though this was relatively small-scale practitioner research, there were still power relations at play as there are arguably power relations present in all settings (Brooks, Te Riele & Maguire, 2014). Teachers have a degree of power over their pupils and this influence may make it harder for pupils to refuse consent as they are not accustomed to refusing a teachers' request. Indeed, some pupils have the mindset that teachers cannot be challenged or disobeyed (Wong, 2016). To counteract the issues of power relations and informed consent, steps were taken.

Cohen, Manion and Morrison (2018) say that to counteract power relations pupils should be put at ease, treated as important and the experience should be made as positive as possible. This was done in this study by telling the pupils not to think of me as their teacher for the duration of the semi structured focus group interview. The same group interview was also conducted in a familiar setting with chairs arranged in a circle to indicate that all were equal. Pupils were offered biscuits to try and make it a positive experience. During the group interview and when pupils completed questionnaires after a lesson, they were reminded that it was perfectly ok for them not to take part and they did not have to answer if they did not want to. Finally, pupils were told not to put their names on their questionnaires, so their answers would be anonymous, and to drop their completed ones in a box positioned in the cloakroom so that I could not see who had chosen to take part. Along the lines of anonymity, pupils in the focus group interview were also told that no comments they made would be attributed to their names and that they would be given pseudonyms in the write up which would protect their identities but allow for their genders to still be determined.

All data collected, digital and physical, were stored in secure locations with only myself and my supervisor allowed access. Hard copies of data from questionnaires, interviews and surveys were destroyed on completion of the research.

Chapter 4: Findings and Discussion

In this chapter, key findings from the research will be presented. Points of interest that arose from the findings will be discussed and critiqued in light of relevant literature.

4.1 Findings

This study produced three distinct sets of data. First, data was collected from a semi-structured pupil focus group interview. Second, teachers responded to a questionnaire. Finally, data was collected during the study's intervention stage where pupils completed surveys in relation to their views on lessons and tasks. Data was used to answer the research questions presented in chapter two. Findings from the data collection relevant to answering each of the research questions will now be presented.

<u>1.) What do pupils find exciting about science at school?</u>

- What do they like currently?
- Is there anything they would like to try or do more of?

Data collected during the semi-structured pupil focus group interview was able to answer these questions. As described in the methodology, this data came from a randomly selected group of pupils in year 5/6.

Several questions were planned to be posed to the group, but not all were asked as the natural progression of the discussion meant that all the questions were answered. In general, pupils were eager and enthusiastic to talk about their learning and opinions. The enthusiasm and points pupils raised gave me the overall sense that the pupils interviewed during this focus group felt very positively about both their science learning at school, but also science in general. When posed the question if they enjoyed learning science at school there was a lot of nodding and positive responses. Reasons for enjoying it included that they liked learning new facts to the excitement of carrying out experiments. For example one pupil said,

'I enjoy the experiments that we do because they are fun. Like recently, I've really liked all the stuff with the torches we've been doing.'

Michael (aged 10)

Pupils named several activities that they found exciting in lessons. The main cause of excitement was experimenting. They also included researching on computers as a part of this, which was interesting as it is not historically something they have done a lot, due to a lack of internet connected devices in their setting. Discussions were also mentioned as being 'good'.

The pupils' view was that historically they have found most the topics they have learnt about interesting and likeable, but not necessarily exciting. The most popular topics appeared to be Earth and space, light and electricity.

'I love science because it's never boring and we learn lots of interesting things, like space. It's just so mind blowing learning all those big facts!'

Jacob (aged 11)

Of the three topics that were mentioned, two of them had just been learnt in school. This may have been coincidental but as I was also the pupils' teacher, there may have been power relations at play here with the pupils' answers.

Although pupils stated they enjoyed science learning in general, they were easily able to name and discuss topics they had learnt in the past that they were not so fond of and had found mundane. In particular, the water cycle was mentioned by many pupils as being particularly unenjoyable. One particularly disgruntled pupil said, *'It was just so boring. All we did was look at diagrams and match things. We couldn't see or do experiments.'*

Michael (aged 10)

When the interview turned to what pupils would enjoy doing more of and what might make their science lessons more exciting, the pupils had many suggestions, which varied greatly in practicalities. One observation was that the discussion continually led back to the topic of space. One pupil said,

'I would just love to have kept on doing space all year and maybe have started it earlier in school, in other year groups I mean. I love it so much and want to know more, like how do we measure the solar system…'

Florence (aged 10)

At this point all the other pupils jumped in with other topic suggestions for space.

Pupils were undoubtedly passionate about this topic and alluded to the fact that it is a shame that it is such a small part of the curriculum, predominately only taught for a term in year 5 (Department for Education, 2014). Their view was that they would relish spending more time during primary school learning about space and they really hoped secondary school would allow them to do this.

In terms of activities or tasks they might find exciting the answers were most interesting, with many of them being quite unexpected. Unsurprisingly, there was a definite view that more experiments would be welcomed, especially ones that they described as, 'cool and dangerous'. After I probed, it was discovered that what they meant by this was more chemistry-based experiments. When discussing experiments, the group was asked whether they would prefer structured or open ones. The groups answers were split with some saying they prefer a challenge and therefore would like to come up with the question themselves as this helps them learn better, and others saying they would much rather a guaranteed outcome that the experiment will work. Pupils also said they would like to do more discussions but suggested incorporating this with groupwork and researching time on computers.

When asked about doing more drama activities in science lessons the group were not overly positive and were quite wary. The majority said they would not like drama as they would find it too nerve wracking which makes it harder to learn and one posed a curious question to the interviewer,

'Can you actually learn science from doing drama?'

Carrie (aged 10)

This point will be returned to later.

This discussion led to pupils making two, perhaps unusual, suggestions for activities that they would find exciting: making notes during lessons and tests. From what I could ascertain the pupils were referring to note making almost in the style of a lecture, whereby the teacher would talk to them for an hour and they write down what was said. This is not something that one would imagine they have experienced before so it was interesting that several of them suggested it, especially as an exciting way to learn. In terms of tests the majority agreed that they would find tests exciting but there was a consensus that they should not be too hard, perhaps suggesting that what they would find exciting is doing well in a test oppose to the test itself.

2.) What are the views of colleagues on teaching an exciting, knowledge rich science curriculum?

- How confident are they in terms of subject knowledge?
- What do they think are exciting ways of teaching science?
- What are the difficulties when it comes to teaching science?

Colleagues' responses to an online questionnaire, using Microsoft Forms, were used to answer the above research question and sub-questions. All colleagues were teachers at the setting school. 100% of those that were asked responded to the questionnaire, meaning that the data collected showed an accurate insight into the views of colleagues on the topics they were questioned about.

Most colleagues appeared to be confident teaching science. There were slight discrepancies about how confident colleagues felt explaining scientific concepts (25% somewhat confident; 67% fairly confident; 8% very confident) and responses were more varied in terms of confidence for teaching a knowledge rich curriculum in any primary phase (8% not confident; 33% somewhat confident; 50% fairly confident; 9% very confident). In general, it was concluded that colleagues judged themselves to be confident teaching science and in particular, knowledge rich lessons.

Responses showed that all colleagues enjoyed teaching science and all judged that most of their pupils enjoyed their science lessons. When asked to rank their opinion to the statement, 'I think pupils find my science lessons exciting' 90% of the responses agreed with the statement.

For the final question of the questionnaire, colleagues were asked what types of tasks and activities they do in their science lessons, that they think makes learning exciting for pupils. Responses were varied in both detail and number of ideas provided. One clear theme was that every participant specifically mentioned ‘practical work’ or provided an answer with words to that effect, for example ‘allowing the pupils to get hands on’. Roughly half of all the responses only mentioned ‘practical work’ as a means for making science learning exciting and engaging for pupils. Other methods that were mentioned, but in much less frequency, were outdoor learning and groupwork. Although every response mentioned ‘practical work’ there was no consensus as to what this meant or what it constitutes. Some individuals (roughly 20%) specifically wrote about experiments being what they meant by practical work. Within this they talked about, in their opinion, the benefits of both teacher demonstrations and allowing pupils to take the lead and investigate inquiry questions in their own way. Links could be drawn between these descriptions given by colleagues and the definitions of both open and closed inquiry-based learning.

There was undoubtedly a common theme that colleagues believed practical work, in its various forms, was the most effective method to make science lessons exciting and engaging for pupils. The literature reviewed in an earlier chapter of this dissertation does not disagree with this finding and some forms of practical work are certainly seen as an integral part of science education (Kopp and McCormack, 2015; Zimmerman, 2007). However, the vagueness by which it was mentioned raises questions about the types of activities which are commonly used and their overall effectiveness in allowing pupils to make good progress. It should also be highlighted that these were the opinions of teachers, which of course are important and informed, but to my knowledge, were not based on data collected from pupils and were the judgement of teachers alone. It could therefore have been the case that the pupils' actual opinions were very different to those suggested by their teachers.

<u>3.) In what ways do different task/activity types compare when it comes to teaching an exciting, knowledge rich science curriculum?</u>

- What are the pupils' opinions on different task/activity types that could be used for science teaching?
- How effective are different methods for pupil progression and teaching of knowledge?

To collect data that would address this research question a series of lessons were planned and delivered, as explained in the methodology chapter. Pupils involved in the lessons then responded to four statements using a Likert scale ranking. The wording of the statements varied slightly from lesson to lesson, but the overall meaning remained the same. These were:

- I enjoyed this science lesson
- I found this science lesson exciting
- I like the … activity (drama, inquiry or talk inserted as appropriate)
- I understood the I can

The pupils' responses were collated for each lessons data set. Means and standard deviations were calculated for each statement. Table 2 shows the means and standard deviations from each data set, the lesson learning objective and the number of pupils the lesson was taught to. 'School closed' in red indicates lessons that were taught during the period of national lockdown due to Covid-19. During this time schools were closed to all pupils except the children of key workers, those with EHCPs or those considered vulnerable children. This explains why the number of pupils fluctuated.

Table 2: Data collected from series of 9 intervention lessons in Year 5/6. Pupils were surveyed as to their views on 3 task types (talk, inquiry-based learning and drama) and lessons in general.

Task type: Talk tasks	25/11/2020 - Light is made up of many different colours (27 pupils)		26/01/2021 - Begin to classify plants (16 pupils - School closed)		03/03/2021 - Plant reproduction asexual (22 pupils - School closed)	
	Mean response (/5)	**S.D**	Mean response (/5)	**S.D**	Mean response (/5)	**S.D**
I enjoyed this science lesson.	4	**0.9**	3.44	**1.06**	3.91	**1.08**
I found this science lesson exciting.	3.4	**1.1**	3.13	**1.05**	3.23	**1.31**
I liked the 'What if...' discussion.	3.6	**1.31**	3.63	**1.22**	3.64	**1.3**
I understood the I can.	4.9	**0.26**	3.5	**0.71**	4.27	**0.91**

Task type: Drama	02/12/20 - Shadows same shape as object that cast them (27 pupils)		24/02/21 - Plant reproduction (21 pupils - School closed)		17/03/2021 - Animal life cycles (27 pupils)	
	Mean response (/5)	**S.D**	Mean response (/5)	**S.D**	Mean response (/5)	**S.D**
I enjoyed this science lesson.	4.41	**0.83**	4	**0.71**	4.22	**0.74**
I found this science lesson exciting.	4.04	**1.1**	3.9	**0.77**	3.74	**0.89**
I liked the 'Puppet theatre' activity.	4.37	**0.87**	4	**1.26**	4.37	**0.95**
I understood the I can.	4.5	**0.73**	4.43	**0.68**	4.7	**0.76**

Task type: Inquiry-based learning	20/01/21 - Microorganisms (15 pupils - School closed)		10/02/21 - Dichotomous keys (9 pupils - School closed)		10/03/21 - Sexual reproduction (26 pupils)	
	Mean response (/5)	**S.D**	Mean response (/5)	**S.D**	Mean response (/5)	**S.D**
I enjoyed this science lesson.	4.07	**0.85**	3.89	**0.99**	3.77	**1.05**
I found this science lesson exciting.	3.93	**1.05**	3.67	**0.94**	3.19	**0.96**
I liked the 'mould growth investigation' activity.	4.00	**0.93**	4	**0.82**	3.62	**0.84**
I understood the I can.	4.20	**1.17**	4.33	**1.05**	4.62	**0.74**

To better understand the data in Table 2 a series of line graphs were produced for each statement plotting the average responses to the three different task types beside each other. This allowed for comparisons to be made between the task types. These graphs are presented below with general trends and points of interest highlighted in this section. These points and their significance were then considered alongside literature in the discussion section of this dissertation.

Figure 1 shows that generally pupils involved in this study enjoyed all the science lessons where data was collected. The average responses for every lesson, regardless of the task type, was between 3 and 5 meaning they agreed with the statement. Although all the lines are relatively closely grouped, lessons where drama was the main activity appear to have also been the lessons that pupils agreed the most with the statement. No obvious upward or downward trend in the mean responses was visible.

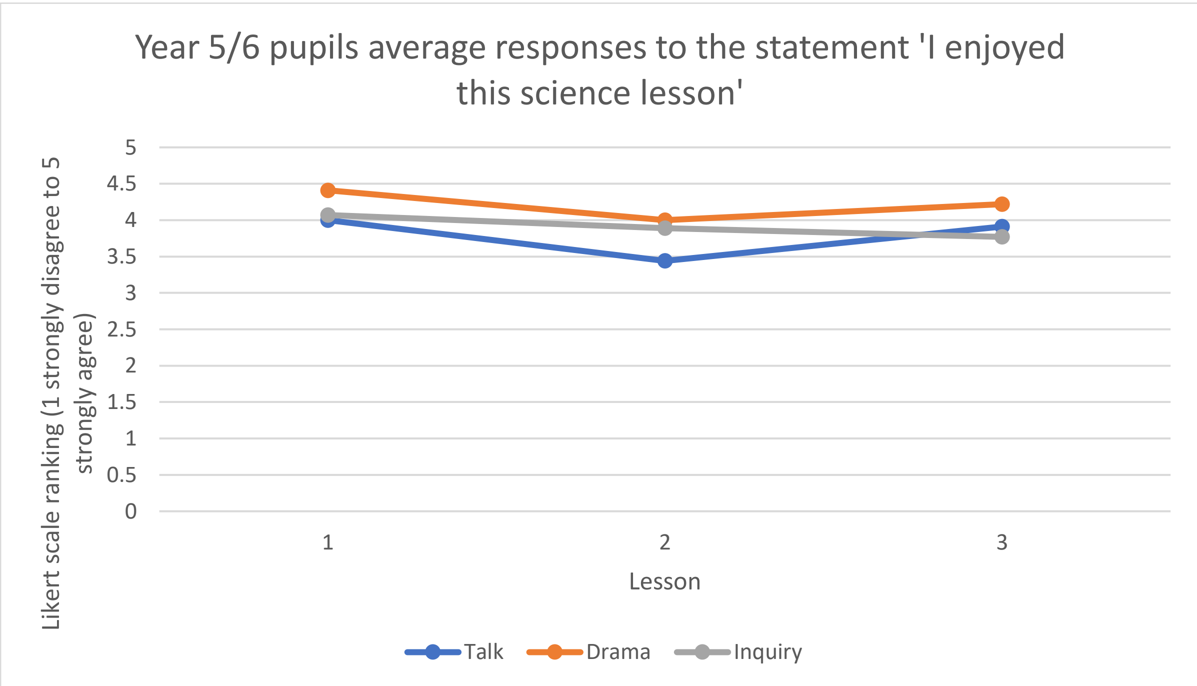

FIGURE 1: DIFFERENCE BETWEEN PUPILS MEAN RESPONSES REGARDING TO WHAT EXTENT THEY ENJOYED NINE SEPARATE SCIENCE LESSONS, CONSISTING OF THREE TASK TYPES.

Figure 2 shows that for every data collection lesson, pupils tended to agree with the statement ‘I found this science lesson exciting’. One could argue that the lessons involving drama and inquiry-based learning seem to have been better received by the pupils than the lessons where a talk task was the focus. In general, the mean responses to the statement in Figure 2 are lower than the mean responses to the statement in Figure 1. This could indicate an apparent difference to the pupils in terms of what is exciting and what is enjoyable. However, some lessons, such as for inquiry lesson 3, the mean responses for excitement were in fact higher than the mean responses for enjoyment.

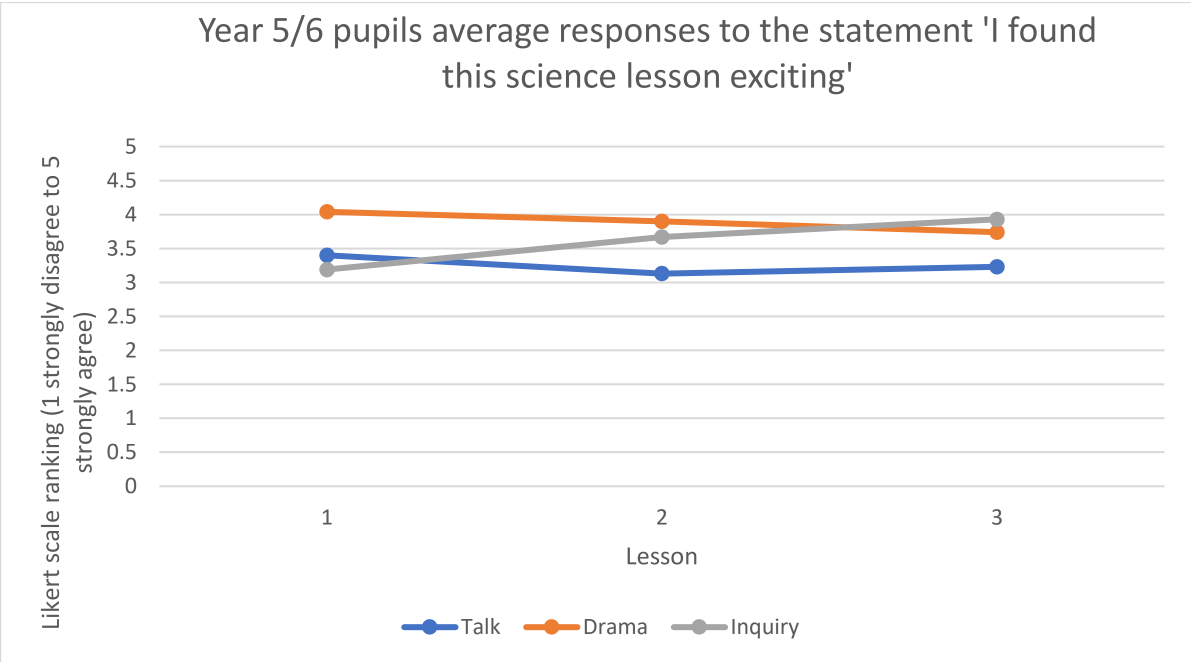

FIGURE 2: DIFFERENCE BETWEEN PUPILS MEAN RESPONSES REGARDING THE EXTENT TO WHICH THEY FOUND INDIVIDUAL LESSONS, OF A SERIES OF NINE LESSONS, EXCITING.

Figure 3 shows data collected in response to statements solely regarding the pupils' opinions of the three task types that formed the basis of the intervention. Once again, the lines for drama and inquiry-based learning tasks were ranked generally higher than talk. All three task types received positive responses, with the average pupil response agreeing with the statement.

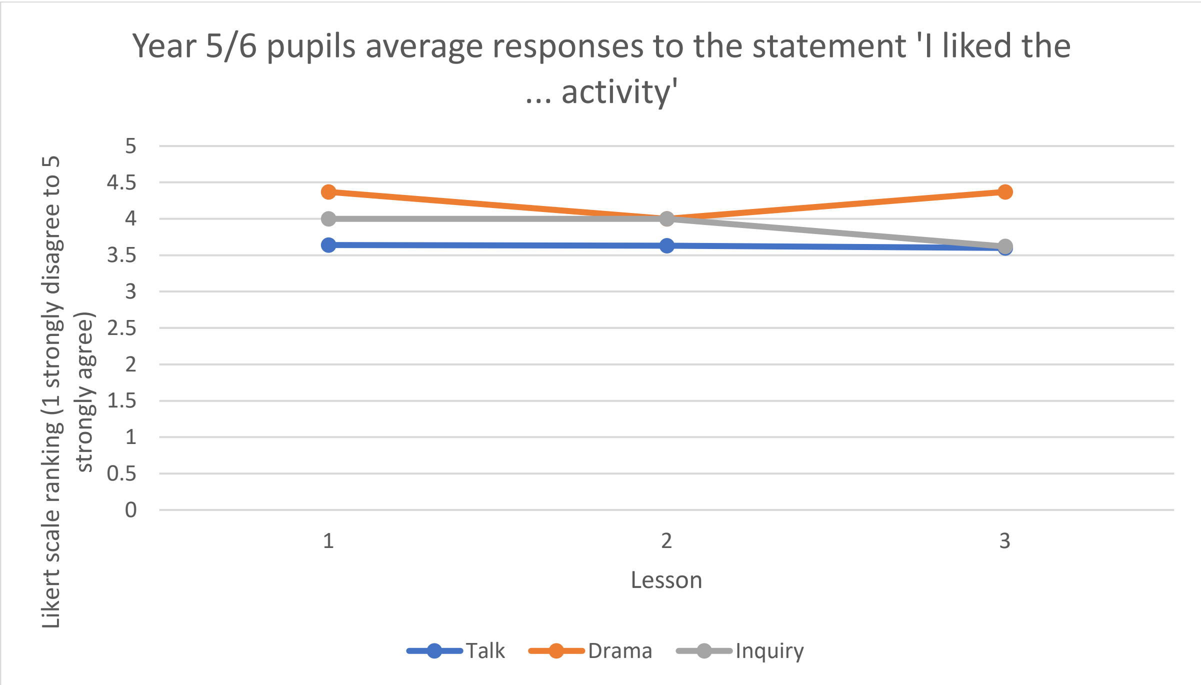

FIGURE 3: DIFFERENCE BETWEEN PUPILS MEAN RESPONSES REGARDING HOW MUCH THEY LIKED THREE DIFFERENT TASK TYPES, TAUGHT OVER NINE INDIVIDUAL LESSONS.

Figure 4 shows no real trends. The data shown is pupils reporting on their level of understanding of the learning. Although pupil self-assessment can be a useful tool, it should not be used as the only method of assessing progress (Black and Wiliam, 1998). For some of these lessons my judgement of progress was like that reported by the pupils, but for other lessons, the opinions were quite different. It should also be highlighted that the topics of some of these lessons were very different and therefore the complexity of what the children were required to learn varied. Due to these factors, the data in Figure 4 cannot be used to draw any trends or conclusions of any worth. Nonetheless, the data from each separate lesson was still of interest to me, purely as an added assessment layer to understand pupils' progress.

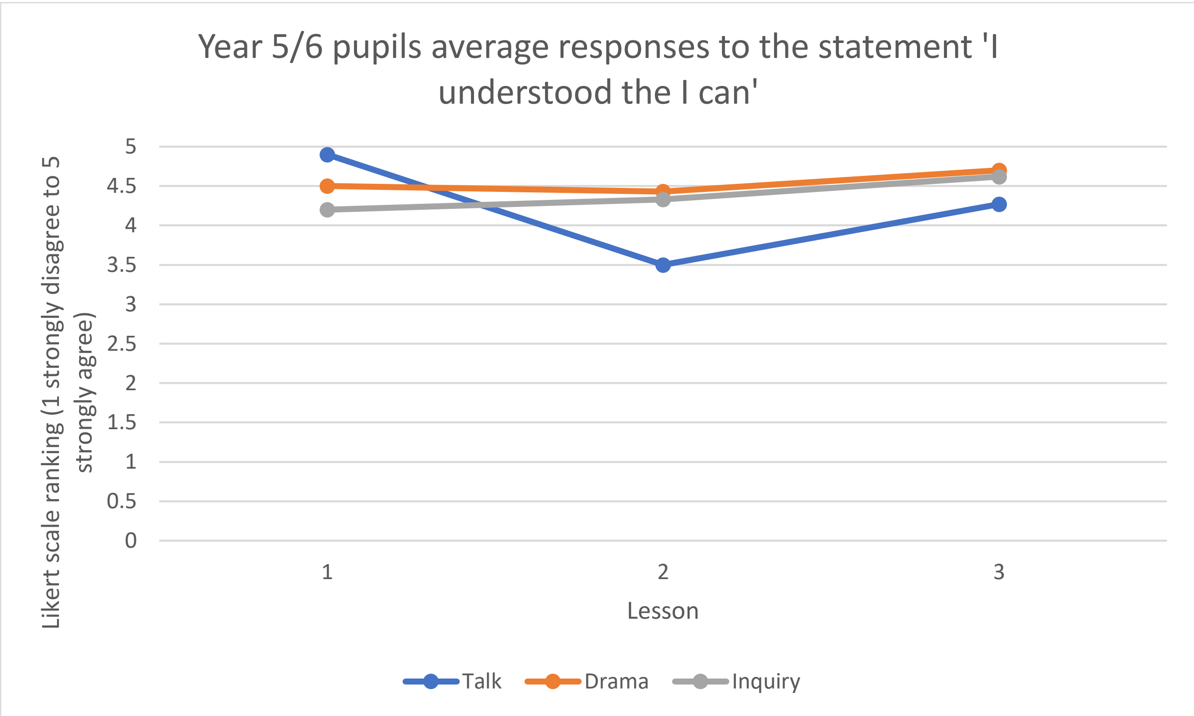

FIGURE 4: PUPILS MEAN RESPONSES WHEN DECIDING THE EXTENT TO WHICH THEY AGREED WITH THE STATEMENT 'I UNDERSTOOD THE I CAN' FROM A SERIES OF NINE INTERVENTION LESSONS.

4.2 Discussion

The findings of the research indicated that both pupils and teachers are generally excited about science at the setting school. During the pupil focus group interview, all six participants had many favourable comments about science and could provide multiple reasons why they found the subject exciting and enjoyed learning it. These pupils had been randomly selected from a class of 30 and provided a fair representation of the different genders, ages and prior attainment levels within the class. One could argue that as they were being interviewed by their class teacher, who they know to be passionate about science, there was a degree of power-relations at play and the pupils were trying to provide me with the answers they think I wanted to hear (Brooks, Te Riele & Maguire, 2014). However, this was deemed unlikely to be the case as the pupils had been put at ease and reassured that their answers could be their true opinions. I also noted that their responses seemed entirely genuine and overwhelmingly enthusiastic.

Teachers reported in their questionnaires an enjoyment for teaching science and a general positive attitude towards the subject. Responses from these teachers also indicated that they believe their pupils find lessons exciting and enjoy learning science. These opinions were supported during the intervention phase of the study, where the data indicated that lessons had been found exciting and enjoyable by pupils.

Although a positive outcome of this research for the setting school, this finding is different to what is reported to be happening globally by much of the literature, where a decline in pupils' attitudes towards science is apparent (Murphy and Beggs, 2005; Porter and Parvin, 2008; Smith, 2011). Much of the literature does indicate that the decline in attitudes starts later into secondary school (Ashbacher, Li and Roth, 2010; The Royal Society, 2006) and there is a clear decline reported over time with fewer individuals reporting to enjoy science as they progress through the school years (Wellcome Trust, 2020). Perhaps then the ages and academic years of the pupils involved in this study is the reason why a general positive attitude towards science is reported, as the decline has not yet started. This would align with DeWitt, Archer and Osborne's (2014) findings, that attitudes remained positive between year 6 and year 8.

One point that arose on several different occasions throughout the research, was the importance of practical activities to both pupils and teachers. This was undoubtedly seen as key to exciting learning. During the pupil focus group interview, pupils often talked about conducting experiments and how much they enjoyed being able to see and do things for themselves. Similarly, allowing pupils the chance to get involved in practical work was mentioned by every participant in the teacher questionnaire, as a method to make learning science exciting for pupils. Arguably all the task types (talk tasks, inquiry-based learning and drama) that formed the basis of the action research cycle phase could be considered learning through practical activities and all were received favourably by the pupils. For many years literature has also highlighted both the prevalence and importance placed on practical work within science education (Barmby, Kind & Jones, 2008; Bennett, 2003; Lemlech, 2009; Millar, 2004).

Undoubtedly, this study found that practical work plays an important role in pupil motivation and engagement as it is seen by pupils and teachers as being an exciting method for learning. These findings echo what others have found, such as Cerini, Murray and Reiss (2003) who surveyed 1400 pupils in England of a range of ages and found that 71% chose ‘doing an experiment in class’ as one of the three methods of learning science they found ‘most useful and effective’. However, the findings do also raise several queries.

Firstly, every teacher participant made mention of practical work, but very few provided detail about what they specifically meant. Practical work within science is such a broad term that it can mean vastly different methods of teaching and learning (Millar, 2011). Therefore, there remains confusion as to what specific methods, on the vast spectrum of the term practical work, teachers were referring to in their questionnaires. This is important as the differences between some of the methods are stark. For example, open inquiry type experiments and pupils simply observing both have their benefits but are vastly different approaches to teaching and learning.

The reason why so many of the responses to this question were vague is unclear. Of course, it could be that participants were time conscious and therefore just wrote down the most obvious response, ‘practical work’. Maybe to respondents they thought it clear what this would mean. However, the frequency and similarity of the response ‘practical work’ from teachers could indicate a different issue that literature has highlighted in the past. Some say that ‘practical work’ is viewed as so essential to being a science teacher, partly for its ability to motivate pupils, that it is now the modus operandi for teaching science and can sometimes come at the expense of finding the most effective way of teaching the learning outcomes (Donnelly, 1998; Millar, 2002). Therefore, it may be that ‘practical work’ is an automatic response for teachers, when discussing the teaching of science, but this does not necessarily mean it is always understood why it should be used. Several have voiced concerns in the past, regarding the effectiveness of practical work as a method of teaching science (Abrahams and Millar, 2008; Hodson, 1991; Osborne, 1993). There may exist an issue with an overuse of practical work and an over-confidence in its effectiveness as a teaching technique. As research has shown (Abrahams and Reiss, 2012), it is of course not the case that all kinds of practical work constitute good teaching practices and in turn lead to pupil progress. Maybe there is a need within science teaching to reinforce what types of practical work are most effective, whilst also highlighting that other methods exist, beside practical work, that can still make learning exciting but also effective.

Although the need for constant consideration as to whether practical work is the best approach for teaching a particular lesson has just been discussed, it was perhaps not surprising that during the intervention phase of data collection the tasks that were most practical (drama and inquiry-based learning) proved to be very popular with the pupils. Although all three task types were generally positively received, the data showed some significant differences between them. Lessons that involved drama tasks were found the most exciting and enjoyable by pupils in this study. Research has spoken before of the positive effects that drama in science can have on pupil motivation, engagement and enjoyment (Abed, 2016; Kentish, 1995; Ødegaard, 2003; Stagg, 2020) and the results of this study do not contest those findings. Pupils' responses to their surveys were clearly favourable for drama, but it was also clear during lessons just how visibly excited pupils were and how much they appeared to enjoy themselves.

Pupils seemed to be surprised by how much they enjoyed drama tasks in science. During the pupil focus group interview, pupils in year 5/6 had been questioned as to their views on the use of drama in science lessons. Most were unfamiliar with the concept, none reported having done any before and the groups' general opinion was summed up by one pupil,

'Can you actually learn science from doing drama?'
Carrie (aged 10)

When questioned about future use of drama in lessons pupils did not react favourably. Most talked about how they would find it too nerve wracking and embarrassing, which in turn they thought would impact their learning. The data shows that the opposite was in fact the case. It was not significantly clear, but a general trend of the data seems to show that drama was the most popular of all the tasks and the one pupils found most exciting. From my point of view, the learning and progress was also good during these lessons, with most pupils at least getting a basic grasp of the scientific knowledge being taught.

Drama proved a useful method to make topics that pupils usually find relatively dull more interesting. The theory of 'plant blindness' (Schussler and Olzak, 2008) and how it leads to pupils having a low level of understanding and many misconceptions regarding the science of plants (Stagg and Verde, 2019) was explored in section 2.5.2. One lesson during the action research phase of research for this study used drama as a means of teaching fertilisation and pollination in flowering plants (Table 2 – **24/02/21**). Contrary to the literature, pupils involved in the lesson found it exciting (3.9 (S.D 0.77)) and enjoyed the drama activity (4 (S.D 1.26)). The reported learning by both pupils (4.43 (S.D 0.68)) and teachers was also good. This indicates that perhaps drama is not only useful for creating positive attitudes towards a subject, but it can also be an important tool for communicating abstract scientific concepts, such as plant fertilisation, that would otherwise be difficult for pupils to understand (Kerby *et al.,* 2010; Peleg and

Baram-Tsabari, 2011). There are also potential benefits of drama being used in the future as a method of teaching topics pupils have found historically less interesting, such as plants.

It was clear that pupils had not participated in a lot of drama during science lessons in the past. Christofi and Davies (1991) found that over 50% of teachers had never used drama in teaching. Thirty years later in this study, no teacher made mention of drama in their questionnaires as a method for teaching science in an exciting way. This perhaps all points to the fact drama remains a rare method for science teaching, or at least within the setting of this study. This is a shame as the benefits for pupil motivation, engagement and learning that are reported in literature and identified in this study, are great.

Talk tasks proved to be relatively popular with the pupils in this study, as for each lesson where they were the main task the means for the pupils' responses were above 3. This indicated that pupils in general agreed, to some extent, with the four statements they were posed, which covered the excitement, enjoyment and learning experiences of pupils in the lessons. However, when compared to the mean responses for inquiry-based learning and drama tasks, talk tasks were significantly lower. There are several possible reasons as to why this may be the case. One simple explanation might be that although talking was enjoyable it was not exciting for some pupils. However, the data in response to the statement about enjoyment was also lower than that of the other two task types, which might indicate this was not the reason.

Another explanation could be how pupils with varying prior attainment levels respond and engage to talk tasks. Evidence of this in this study could be that unlike, with inquiry-based learning and drama tasks most of the reported standard deviations for talk tasks were greater than 1. This may indicate a greater spread in the data, caused by variation in responses from pupils of different prior attainment levels.

It is widely accepted that group discussions and talk tasks can be an exciting way for pupils to learn (Braund, 2009; Howe *et al.,* 2007; Thurston *et* al., 2010) and has a positive impact on academic achievement (Mercer, 2008). However, previous research has also indicated that classroom talk is not experienced in the same way by all pupils (Howe, 1997). Whether or not this difference of experiences has a relation to prior attainment levels remains somewhat unclear. Myhill (2002) found that prior achievement levels are the key determiner in who takes part the most in class discussions, with prior lower-achieving pupils being the most reluctant and least involved. Black and Varley (2008) also found a difference in pupils of different prior-attainment levels understanding their own participation in class discussions. The reason pupils of lower prior attainment are less enthused by talk tasks may be that they simply do not have, or feel they have, the topic knowledge or cultural capital to partake in whole class discussions confidently. It is often the case that pupils who contribute the most in classroom discussions are from middle-class backgrounds, with rich cultural capitals (Black, 2004). Therefore, talk tasks may be too challenging or inaccessible for some pupils. This would surely impact their enjoyment of the lesson and excitement they experience as the task is simply too difficult.

As all the pupils' responses were anonymous, more research would be needed to prove that there existed any significant difference in the attitudes of pupils towards talk tasks based on prior attainment levels. Nonetheless, the literature and discussion suggest that further consideration is required when talk tasks are planned in the future, especially when differentiating to ensure all pupils, regardless of prior attainment levels, can access and enjoy the talk task.

The results of this study show that collectively the year 5/6 pupils found all the lessons they were taught and surveyed on exciting and enjoyable. Over the nine lessons, with three being of each task type, none of the statements that were asked produced a mean response below 3.13. With the pupils having to rank how much they agreed with the statement on a scale of 1-5, a mean above 3 showed that the average opinion agreed with the statements. It could therefore be said that talk tasks, inquiry-based learning and drama are all effective ways of teaching a knowledge rich curriculum in an exciting way. Variations between the three task types were apparent and have been discussed earlier in this chapter but they were all received favourably by the pupils.

Throughout the study it was always accepted that multiple factors, both intrinsic and extrinsic, influence the emotions pupils experience in lessons (Palmer, Burke and Aubusson, 2017). Therefore, each of the task approaches were used in three distinct lessons and a larger number of pupils were surveyed, with an aim to counteract these factors to some degree and ensure as much as possible that the task type was the determining factors in pupils' excitement and enjoyment levels. However, it would have been naïve to think that other influences would not have played some role and it was assumed that the topic being taught would have a significant impact also, as literature showed the strong relationship between a pupil's interest in specific topics and their emotions towards science (Ainley and Ainley, 2011).

The data from this study does not necessarily show this to be the case. Technically, two different topics were taught over the course of this study: 'light' and 'living things and their habitats'. However, the 'living things and their habitats' topic could be thought of as two separate topics because of the mixed year groups at the setting school. As the science curriculum is taught over two years, the year 5 and year 6 'living things and their habitats' topics are merged and taught as one large block. Therefore, three topics were taught during this study as the 'living things and their habitats' topic could be broken down into 'classification' and 'life cycles'. Although the assumption had been that these topics would be received differently by the pupils, the data shows no obvious significant difference between the topics. This suggests that in this study, the topic being taught had little influence on the excitement pupils experienced. This could link to what Reeve *et al*. (2004) found, that the role of the teacher is more important for influencing pupils' emotions than topics.

This study identified no significant differences between the topic being taught and pupils' attitudes, but there is an argument that the curriculum for primary aged pupils is not designed and catered to their interests. During the pupil focus group interview, pupils repeatedly mentioned how they would like to learn about the 'big ideas' in science. These included such topics as the big bang theory, human cell biology and chemical reactions. They said they would find these exciting and it was what they would choose to learn if the choice was theirs. Although these topics may be touched upon in lessons, they do not form a part of the primary national curriculum (Department for Education, 2014). Others have discussed similar ideas and go as far to say that what we teach in primary classrooms bores pupils and we leave it until secondary school to teach the interesting topics, by which point pupils' curiosity has abated and it is too late to feed and create an enduring passion for science (Haeusler & Donovan, 2020). The idea that younger children cannot cope with the more complex ideas in science may be down to narrow interpretations of Piaget's (1936) theory of cognitive development. However, several studies have challenged this theory and indeed shown that younger pupils can understand complex scientific concepts if they are adapted suitably (Brown, Rushton & Bencomo, 2008; Donovan & Haeusler, 2015; Murphy, 2012). As previously stated, this study appeared to find that the topic being taught had little to no impact on pupils' attitudes towards a lesson, but this finding should not be interpreted to say that the current curriculum is found exciting by pupils and arguably a wider discussion needs to be had regarding the primary science curriculum and how it may be adapted to cater more to what pupils actually wish to learn, alongside what is required key knowledge.

Partly due to the scope of this study, but also the impact of Covid-19 on the methodology, comparisons between different teachers' and pupils' opinions on lessons could not be explored fully. There is undoubtedly a strong case to be made that the teacher plays an integral role in pupil engagement in science lessons and excitement experienced (Palmer, Burke and Aubusson, 2017; Tytler and Osborne, 2012). In particular, the subject knowledge of individual teachers has been consistently linked with adversely impacting curriculum delivery (planning, teaching, differentiation and assessment) which in turn impacts the quality of pupils' learning experiences (Holroyd and Harlen, 1996; Tytler and Osborne, 2012). All the lessons in this study were taught by myself, who is passionate about science but also has a science background (educated at undergraduate degree level). I was solely responsible for planning the lessons, which had been thoroughly prepared - possibly more so than an average lesson. Reflecting on my own practice, the lessons themselves were taught with great enthusiasm, which is not uncommon for my science lessons as it is a subject for which I have great passion, but these lessons were perhaps taught more enthusiastically, due to the fact I knew they were a part of my research and were therefore important at a personal level. Pupils therefore had a teacher, delivering the lessons who was knowledgeable and enthusiastic. The exact impact this had on their enjoyment and excitement levels experienced during the lessons is unclear, but when considering the literature, it surely played a role. If the chance arose, it would be interesting to research this area further in the future.

The need for science lessons to be practical is a key point that has arisen time and again throughout the data in this study. Literature points to practicals being important for pupil engagement and progress and learning (Gillespie & Gillespie, 2007; Kopp and McCormack, 2015). This study has also found and proposes that a practical approach is a key way to teach exciting, knowledge rich lessons. During a session, where colleagues were asked to analyse data and provide their opinions, a professional discussion ensued that discussed the implications of a more practical science curriculum for primary school teachers. Although all agreed that it is the best approach for pupils and their learning, there was trepidation and nervousness from some. Time was discussed as a limiting factor. Few primary schools have assistants to help set up classrooms for science lessons meaning that often preparation for science practicals must be completed by the class teacher and during their lunch hour. Even then, there is sometimes not time to set up all the practical tasks and experiments that a teacher may wish. There was mention of a desire for additional PPA time to prepare solely for science lessons. Realistically, the chances of this happening are slim, but theoretically the concept would provide some form of a solution.

Another limiting factor raised was classroom space as usually primary schools do not have dedicated science laboratories, meaning science lessons occur in the main classroom. Arguably, these are not areas well designed for such activities and this brings into question a greater issue as to whether one of the biggest challenges to teaching science in primary schools is in fact the practicalities and access to resources. Data from this study and others suggest that by the time pupils are in the later years of primary education they are thirsting for more exciting science activities and enjoy the practical aspects of learning (Barmby, Kind & Jones, 2008). Yet research shows primary teachers say they only have access to 46% of the equipment that they need to teach practical science effectively and the average school is only able to access two thirds of the recommended outdoor learning space required to teach the science curriculum (SCORE, 2013). Therefore, for many schools a lack of resources and appropriate space plays a contributing factor to limiting just how exciting a primary science curriculum can be.

4.3 Limitations

Although actions were taken to ensure scientific rigour and reliability, this study still had several limitations, some of which were connected to the impact of the Covid-19 pandemic. The mere existence of the virus was a limitation as normal classroom routines were affected. This ranged from staff having to social distance from pupils to pupils not being able to touch each other's possessions. A nationwide lockdown and the closure of schools to most pupils during the data collection, meant that data for this study was collected from two different groups. The first was an average class in the setting school, consisting of a maximum of 30 pupils if all pupils had been present on the day of data collection (which was not guaranteed as many pupils were required to self-isolate throughout the year). The second group consisted of between 9 and 22 pupils, of which a much larger than average proportion were SEN or had an EHCP. National data from 2019 shows that in England 14.9% of pupils were SEN and 3.1% of pupils had an EHCP (Department for Education, 2019). In this study the percentage of pupils in the second group who were SEN was 41%, whilst the percentage of all pupils who had an EHCP was 23%. This was very different to the first group, the year 5/6 class, where 17% of pupils were SEN and 7% of pupils had an EHCP. The exact implications of how this may have impacted the data is unclear. These pupils were still fully able to offer their opinions on lessons and tasks and all responded to the surveys with relative ease as they were differentiated to make them more accessible. However, the fact remains that the second group of pupils who provided the data were unrepresentative of an average classroom in England.

Covid-19 also meant that the number of participants was limited; even more so once schools closed to most pupils. For one data collection lesson only 9 pupils were present, which is a small sample size. Therefore, it could be argued that the data collected was insignificant and the extent to which it can be acknowledged is limited (Slavin and Smith, 2009). However, to some degree practitioner research always has a value as it can increase teacher knowledge and can therefore lead to development at either a personal or school level (Goodnough, 2011; Zeichner and Noffke, 2001). It could certainly be argued that this was the case during this study, as at a minimum the data will have an influence on my practice.

Another limitation of this study was that even though it was aiming to look at the impact of different tasks on pupils' attitudes, there is always going to be a variety of extrinsic and intrinsic factors that influence the extent to which pupils find lessons exciting. One example of this would be that it is unlikely that over the course of nine lessons I taught each one with the exact same level of enthusiasm. It could also be the case that a bad break time immediately before the lesson, perhaps a wet break where pupils had to stay inside, would have influenced some pupils' feelings towards a science lesson, as they would have been poorly motivated for the afternoon whatever the activity.

A final limitation, that was discussed in the ethics section of Chapter 3, was the impact that power relations may have had on the data. Pupils completed their surveys anonymously, but they still knew that the researcher was also their teacher. For several reasons ranging from a desire to please their teacher and win favour to a misplaced fear of retribution if they did not answer favourably, there is a chance that pupils may have inflated their survey scores because of the power relations in play. Therefore, the mean scores may not be fully representative of the actual views that were held by the pupils.

Chapter 5: Conclusions

The research aim of this study was to explore how we teach an exciting knowledge rich primary science curriculum.

This aim was broken into three research questions which were:

- What do pupils find exciting about science at school?
- What are the views of colleagues on teaching an exciting, knowledge rich science curriculum?
- In what ways do different task/activity types compare when it comes to teaching an exciting, knowledge rich science curriculum?

This chapter will present conclusions drawn from the investigation in answer to these research questions and explain the implications the findings have had on my professional practice, the setting school and beyond.

This study showed that most pupils involved found science exciting, felt positive about science and enjoyed their learning. Discrepancies were raised between what the pupils would like to study and the national curriculum. One point that came up several times was how pupils would like more time dedicated to certain topics and that they desire to learn about the 'big ideas' of science. This is something that the national curriculum does not cater for at a primary level. Pupils highlighted how important practical activities were for making learning exciting and they mentioned experiments and investigations as being important. The importance of practical activities in science for both the pupils and teachers involved in this study is one of the key conclusions that came out of this investigation.

The second research question related to colleagues and their views on teaching science. This study found that teachers at the setting school were generally confident about teaching science and enjoyed doing it. The overwhelming response when asked how to make science exciting for pupils was around the idea of practical activities and making the learning hands on for pupils. Finer details of what they meant by this was unclear. At various points of the study, issues around the teaching of science were raised including time, access to equipment and the learning environment of a primary school. The conclusion to take from these findings was that the setting school has a teaching staff that feel positive about science and teaching it. This undoubtedly contributes towards positively influencing pupils' attitudes towards the subject. This may have been evidenced by the general positive attitude pupils in the focus group had towards science.

The three task types that were explored as part of this study were all effective at delivering lessons that the pupils found exciting. However, there were some clear differences in attitudes towards each task with the general order of most to least popular being drama, inquiry-based learning and finally talk tasks. One clear conclusion from this study was the popularity of drama activities with the pupils and how effective they were at making the lessons exciting and enjoyable for them. The literature was split about the benefits of drama for knowledge retention as some suggested there was little (Dorion, 2009; Metcalfe *et al.*, 1984) and others contested this (Stagg and Verde, 2019). This study found no conclusive evidence for either side of the argument but recognised that there are still obvious benefits to having tasks which engage pupils with their learning.

This study has had several implications on my practice. Firstly, before I undertook this study, I had little knowledge of the use of drama and theatre in teaching science and during my three years since qualifying I had never once observed, heard mention of, or taught myself, a lesson with a drama activity. Influenced by both literature and positive responses from pupils during this study, I will use drama much more frequently and will encourage my colleagues to do the same. Reservations remain about using it as a main task, mostly due to the lack of evidence around the benefits for increasing pupils' knowledge, but I plan to use it as a starter activity in lessons to hook the pupils into topics.

A second way this study has influenced my practice is how I will use talk tasks in my science lessons from now on. The spread of the data collected from the talk tasks made me think about how pupils of differing prior attainments and socio-economic backgrounds engage with talk tasks and how they may, for many reasons found in the literature (Black and Varley 2008; Myhill, 2002), be more accessible and enjoyable for prior higher-attaining pupils and those from higher socio-economic backgrounds, who have greater cultural capitals. This led me to think about how I need to further differentiate talk tasks when I use them in lessons, to ensure that all pupils can access the discussion and thus the related benefits.

This study has also influenced how I will approach my science leadership. One of the drivers behind this study was the desire to find an approach to teaching science that is exciting for pupils and delivers key subject knowledge, then to possibly use these findings to pick a whole school scheme that we may be able to adopt. Having completed this study I feel that I understand better the type of scheme that would be appropriate and, perhaps more importantly, the type of scheme that would not. At the time of writing, I have not found a whole school scheme of work that fits my new criteria and I do still feel strongly that there are benefits for not using a scheme, both financially and educationally. A conversation regarding this matter will have to be had with SLT, but I now feel that I can enter this with a strong, evidenced based argument.

There were several wider implications of this study within my school. Findings regarding lack of equipment and suitable space for primary science lessons have led to discussions with the local secondary school about possible use of their laboratories and equipment for some of our science lessons, hopefully in 2021/22. As science lead, I am going to plan and implement an annual science week at our school from now on, which will have a strong focus on practical activities, as a way of developing and maintaining excitement around science.

Throughout the course of this study areas of possible further research were highlighted which may be of interest to explore in the future either personally, or for others who have read this dissertation. These included: the impact of drama in science lessons on pupil progress; comparing how pupils of differing prior attainments respond to talk tasks within science lessons; and whether teachers' confidence levels in teaching a subject is a good indication of subject knowledge. Finally, this study has discussed the appropriateness of the national curriculum for primary science and the role it has in influencing pupils' attitudes towards the subject. There is perhaps a need to review what is being taught in science at primary schools nationally and whether a different approach is required, that may better develop in pupils, a passion for the subject and therefore ensure their longevity of pursuing education in science.

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Appendices

Appendix A

Question schedule for semi-structured pupil focus group interview

1. Do you enjoy learning science at school? Why/ why not?
2. Do you think the topics we learn about are interesting?
3. What would you like to learn about in science lessons?
4. What do you like about science lessons?
5. What things do we do in lessons that you find exciting? (Participants will be shown some pictures of different activities we have done in the past)
6. What would you find exciting in lessons?
7. What things would you like to do more of/ try out in our science lessons? (Participants will be shown pictures to prompt ideas)

Appendix B

Prompt images used during semi-structured pupil focus group interview

Appendix C

Question schedule for teacher survey

Teaching science

Thank you for taking the time to complete this questionnaire. As some of you may know, I am studying for the Master's in Learning and Teaching at Oxford University. For my final research project I am exploring ways of teaching a knowledge rich primary science curriculum, in an exciting way for pupils and I would be grateful for your opinions.
The answers you provide below will be used as data, for the study, unless you indicate otherwise. All participants will be made anonymous in all research reports. The data collected will be kept strictly confidential, available only to my supervisor, and I, and only used for academic purposes. It will be kept for as long as it has academic value. If you would rather your data not be used, please indicate this in question one below. If you complete the questionnaire and then decide at a later date that you would rather your data not be used, please just let me know and it will not be included in the study.
Once again many thanks!
[redacted]

1. I am happy for my responses to be included in the study.

◯ Yes

◯ No

2. How confident do you feel about the below?

	not at all confident	not confident	somewhat confident	fairly confident	completely confident
Explaining scientific concepts	◯	◯	◯	◯	◯
Teaching a knowledge rich science curriculum in your phase	◯	◯	◯	◯	◯
Teaching a knowledge rich science curriculum in any primary phase	◯	◯	◯	◯	◯

3. To what extent do you agree with the statements below?

	strongly disagree	disagree	neither agree nor disagree	agree	strongly agree
I enjoy teaching science	○	○	○	○	○
Pupils in my class enjoy science lessons	○	○	○	○	○
My science lessons are exciting for pupils	○	○	○	○	○
My science lessons are knowledge rich	○	○	○	○	○

4. What types of tasks or activities do you think makes learning exciting and engaging for pupils, in your science lessons?

Appendix D

Example of post lesson pupil questionnaire

Topic: Living things (Lesson 9) **Date:** 17/03/21 **Task:** Drama (Life cycles)					
	Strongly Disagree	→			**Strongly Agree**
	1	**2**	**3**	**4**	**5**
I enjoyed this science lesson.					
I found this science lesson exciting.					
I liked the drama activity.					
I understand animal life cycles.					

Appendix E

CUREC approval email

Dear [redacted],

Title: How do we teach a knowledge rich primary science curriculum, in an exciting way?
Ref: ED-C1A-21-042

The above application has been considered on behalf of the Departmental Research Ethics Committee (DREC) in accordance with the procedures laid down by the University for ethical approval of all research involving human participants.

I am pleased to inform you that, on the basis of the information provided to DREC, the proposed research has been judged as meeting appropriate ethical standards, and accordingly, approval has been granted.

Should there be any subsequent changes to the project which raise ethical issues not covered in the original application you should submit details to student.curec@education.ox.ac.uk for consideration.

Good luck with your research study.

Yours sincerely,

Laura Molway
Member of DREC