Biology Autobiographies: How do Personal Subject Experiences Influence Biology Teachers' Pedagogical Thinking?

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A dissertation submitted in partial fulfilment of the requirements of Sheffield Hallam University for the Doctorate in Education

August 2020

Candidate Declaration

I hereby declare that:

1. I have not been enrolled for another award of the University, or other academic or professional organisation, whilst undertaking my research degree.

2. None of the material contained in the thesis has been used in any other submission for an academic award.

3. I am aware of and understand the University's policy on plagiarism and certify that this thesis is my own work. The use of all published or other sources of material consulted have been properly and fully acknowledged.

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Acknowledgments

This thesis was completed with the help and support of many people.

I would first like to thank my participants for their generosity with their time and their stories, it was a privilege to work with you.

Secondly, my Director of Studies, Professor Cathy Burnett and my second supervisor, Dr Stuart Bevins, thank you both for your expertise, patience and positivity. It has been a long journey and I have learned so much from both of you.

Numerous colleagues have provided moral support and acted as sounding boards – thank you all.

Finally, I would like to thank my husband, Dave Scott, for his unwavering support and belief.

Abstract:

The aim of this study was to explore practising biology teachers' perceptions of the factors influencing their current beliefs about teaching biology and their pedagogical decisions.

This was a qualitative study that used a sequence of three semi-structured interviews with each of five participants each with a range of years in post, to collect data in the form of their narratives about teaching biology. The study followed a constructivist grounded theory design to guide the collection and coding of data from the interview transcripts. A constant comparative analysis of the data was used to suggest categories and relationships between them, using abductive reasoning to generate conclusions that had the potential to inform professional practice in Initial Teacher Education programmes and approaches to early career support for teachers.

The study suggested three areas of interest. Firstly, the teachers' expressed beliefs about teaching biology and the factors that were influencing these. There was a large degree of similarity between the participants who explored the complexity and breadth of the subject; an underestimation of the subject by colleagues with other science specialisms; and the need to teach for deep understanding. In contrast to a number of other studies that identified early, informal experiences with the subject as key factors in developing biology teachers' beliefs, the participants in this study identified their own experiences as pupils at secondary school and their growing understanding of their subject while in post as key influences.

Secondly, participants told stories about the impact of working with others, including a growing empathy with, and understanding of, the individual pupils in their classes and pedagogical support from knowledgeable others. These findings are discussed in relation to research from the 1990s that argued for the importance of 'knowing pupils' and current literature around teacher knowledge. The thesis proposes that, what I refer to as 'reflexive empathy,' which involves considering how pupils might be responding to being taught the subject, is an important aspect of developing teacher practical knowledge.

The final area of interest concerned participants' perceived amount of pedagogical agency as a factor in their day-to-day classroom decision making. This is considered in relation to a theorisation of agency as contextual and situated rather than as a characteristic of the individual, and the impact of the school context is discussed. One of the significant ideas emerging in this regard was the need for explicit permission to be pedagogically innovative, whether through departmental or wider school culture or through collaborative work with colleagues.

This study has implications for professional practice in programmes to support pre-service biology teachers and also supporting early career teachers, particularly in light of the introduction of the recent Early Career Framework.

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Introduction to this study: from personal experience to research question

This study began with stories. The first story was my own, I was telling a teacher education colleague about my personal journey to becoming a biology teacher. I cannot remember the exact context, but the story stayed with me and made me think about how I got to be the kind of teacher I was and how that had influenced my journey into teacher education. Later I tried to capture the story as naturally as possible by just writing what came into my head although I suspect that, like all stories, it has changed slightly since that first telling.

Personal story: Early experiences with biology and the journey to teacher training

I have a number of extremely vivid memories of my early engagement with what I now recognise as biology as a subject. Many of the experiences pre-date formal secondary education although I am not always sure of dates or sequence and most of them involve interaction with the natural history around my home. One of my first memories is about the natural history of Singapore where my family lived for several years on an army base - which must mean that I was somewhere between the age of 5 and 8 years old. I remember watching huge ants on my way to school and charting their lives and behaviour over the year. I remember going out into the garden at night with my dad to record the sounds of nightjars and bats on our portable tape-recorder. I remember studying the lizards and moths that visited the palm trees in the garden.

Moving forwards several years to my return to England and I remember sitting with my cousin's wife, a nurse, and trying to learn about the structure of the human body from her textbook.

Throughout my time at middle school and early secondary school I was an avid botanist, although I would not have referred to myself in that way at the time, collecting wildflowers that grew on waste land and in the local field edges, a copy of 'The Concise British Flora' on almost permanent loan from the local library. I had been looking forward to secondary school and the prospect of real science lessons for so long. I imagined what chemistry and physics lessons would be like.

The main thing that I remember about secondary school science was a crushing disappointment: sitting in lessons that involved copying diagrams into my exercise book; trying to talk to a physics teacher without any time to talk to me about a picture of a molecule taken with some sort of scanning technique; endless dictation. As a fairly pragmatic child I simply compartmentalised, school science became something very separate from the things that I was interested in. I could complete diagrams of a cross-section of a leaf from a textbook but didn't consider this science. Meanwhile at home I read books on animal behaviour and used the little microscope that my Mum and Dad had bought me for Christmas to look for amoebas in puddle water.

Even after doing a degree in biology, which was a variable but mainly engaging experience, I never once considered becoming a school biology teacher. These were the people who had turned my interest into tedium. It's a good thing I was a fairly compliant pupil.

My teaching epiphany came much later, after a tedious year in a factory laboratory, during my time as a college science technician. My microbiology expertise was called upon. I very nervously worked with a class of college students alongside the teacher to demonstrate some techniques for practical work and something just fell into place. I began to read about science teaching and found myself interested in the

new approach to science in schools: process science; investigative approaches; the emphasis on thinking and experimenting like a scientist. This wave of thinking in the 1980s seemed to represent everything that I had wanted from my own school science. Things were changing … this was my mission …

In this introductory chapter I give a brief outline of my approach in order to set the context for my study and state my research questions. I will then explain how reflecting upon my personal journey to becoming a biology teacher led to the realisation that this story held clues to my personal beliefs about science, and in particular, biology teaching. Having made the transition from biology teacher to biology teacher educator a number of years ago I found myself in a position that required me to consider and justify my ideas about 'good practice' in pedagogical approaches. It was through telling my own stories about my journey to becoming a biology teacher and listening to the stories that my students told about their experiences of biology teaching that my research questions emerged. The story above is a version of the story that started my thinking and from which my research questions evolved. It became clear from my interaction with the literature that my own experiences with my science discipline and the stories that I was telling about them were an integral part of the way in which I made sense of my approach to teaching biology and contributed to how I made sense of the stories that my research participants told.

Listening to Initial Teacher Education students' stories

After many years as a secondary biology teacher, I made the transition to teacher education and met the next set of stories. These stories were just fragments, really. Small insights into my students' journeys to becoming science teachers as I went

about the day-to-day business of working with cohorts of pre-service science teachers on a Post Graduate Certificate of Education (PGCE) course in their biology subject pedagogy sessions at the university. I did not capture these stories systematically, but I began to ask for them more formally as a preparation to university sessions designed to get them thinking about biology teaching. I began to ask students to share their experiences of being taught biology themselves. Not all the students were planning to be biology specialists, but they were all planning to be secondary science teachers and I noted some of these comments to use in my later sessions.

I will try to share a flavour of their comments because I was initially surprised that many of them echoed my own experiences of being a pupil.

> *All we did was copy diagrams.*
>
> *I never felt that it was proper science.*
>
> *Boring … I don't like plants!*
>
> *I didn't really like it – there didn't seem to be anything to understand, it was just about learning facts.*

But some of these people clearly intended to become biology teachers and for some of them, this was because they wanted to change how biology was taught. It made me consider whether anything had changed in the 30 or 40 years since my secondary school experiences and theirs. It made me start to think about biology as a subject. What was going on? There did not seem to be a shortage of pupils choosing to study biology at A-level, students choosing to do biology-related degrees

and post-graduates choosing it as a PGCE subject, but it seemed that some of the same dissatisfactions were being expressed each year.

However, my students also told stories about inspiring biology teachers, teachers with wonder and passion for the subject, teachers who had been the inspiration behind people wanting to teach the subject themselves. I also thought about my time as a teacher, and I realised that perhaps I had worked with a couple of very like-minded colleagues for a long time and that it was likely that not all biology teachers thought the way I did. These stories made me start thinking about how I might find out about practising biology teachers' thinking. Why did they do the things that they did? What made them think about biology in a particular way? What was influencing them? Were their stories, like mine, a desire to change bad experiences? Or were there positive influences out there?

In light of this I became interested in the factors that might be influencing biology teachers' classroom decisions and decided to focus my study on teachers' perceptions of how their previous experiences were influencing their approaches to biology teaching. I also decided that teachers' stories would be my data and that after nearly 30 years of seeing the world as a scientist I would need to reconsider what I saw as 'data', how I saw my role as a 'researcher', and how I made sense of some aspects of the world. This was not something that I had really considered before and I began to realise that I had simply taken the whole social world for granted. It was time to question the scientist in my head and think about how narratives might be used as data.

Outline of the approach and research questions

This study aimed to explore how biology teachers make sense of their current practice in terms of their previous experiences with their subject, including those experiences outside formal education, and how they feel that they integrate these experiences into their teaching. I was interested in how previous experiences might be shaping other biology teacher's beliefs about biology teaching and whether those teachers perceived any barriers to their classroom approaches. Finally, I wanted to consider the implications of any findings for those of us involved in teacher education programmes in biology.

My three research questions were:

1. What are biology teachers' expressed beliefs about teaching their subject?

2. What are biology teachers' perceptions of the way in which previous experiences with their subject have influenced their beliefs about teaching biology?

3. What are biology teachers' perceptions of how they can implement their beliefs in the classroom?

As my aim was to explore individual teachers' perceptions of how subject experience might be influencing their beliefs and so their classroom practice, I adopted a constructivist paradigm, taking an epistemological position that recognises that realities about teacher knowledge, values and beliefs are co-constructed and contextual. This is discussed in more detail in Chapter 3.

Kelchtermans (1993) highlights the importance of the 'professional biography' as a tool for research, arguing that if teachers are encouraged to present their professional experiences as an 'autobiographical story' (p. 444) it allows the

researcher to focus on the meaning that events have for the participant. The teachers' conceptions about teaching, and in this particular case, teaching a specific subject, are constructed as the story is told. I was strongly influenced by grounded theory and attempted to generate theory from empirical data although I did not follow the strict approach suggested by Glaser and Strauss (1967) but used the modified approach suggested by Charmaz (2014). Grounded theory as a research approach allows for the discovery and conceptualisation of patterns in data through a constant comparative approach. Initially my approach was inductive and was then followed by a deductive phase in which I formulated the questions that I wanted to ask next. The data were generated in a series of semi-structured interviews / conversations. I provide detail on the design of this study in Chapter 3 and details of the data analysis in Chapter 4.

Thesis structure

Chapter 1 sets the context for the study and includes a reflection on my experiences of teaching biology at secondary school and latterly teaching beginning biology teachers and a review of current thinking about biology teaching in English secondary schools. The chapter outlines my approach and states my research questions.

In Chapter 2 I present a literature review that allows me to expand on how teacher knowledge is understood in this thesis, how it links to beliefs and informs my understanding of the concept of ‘pedagogical decisions’ from my title. This chapter also informs the discussion around my findings in later chapters.

Chapter 3 details the methodology and design of my study. It begins with a discussion of the two key theoretical strands that underpin my approach, the use of

personal stories as data and the grounded theory methodology. I also explore my journey towards an epistemological and ontological position. I felt that this required explanation and a reflection on my journey as this study represents a considerable shift in my thinking about data and generalisation. In the second part of the chapter, I give details of the methodological steps taken in the study including sampling and data collection and discuss the ethical considerations of the study.

Chapter 4 provides detail around the data analysis process and includes examples of my approach and details of the coding process and data distillation approaches taken. More details can be seen in the appendices that are referenced in this chapter.

In Chapter 5 I present my findings using my participants' words and my commentary to explore their perspectives. I also present relational diagrams that illustrate my interpretation of how categories and themes identified from the data link together. Having identified key themes, I then discuss these in Chapter 6, relating my interpretation of the data to relevant literature and summarising my conceptualisation of my findings.

In the final chapter, Chapter 7, I summarise my interpretation of my analysis and relate this back to my initial research questions. I include a statement of the study's contribution to knowledge. I then consider how this study's findings might be applied to my practice as a teacher educator and look at the implications for wider practice. The thesis concludes with an evaluation of the study and possible directions for further research.

Chapter 1: setting the context

1.1 Introduction

In this chapter I will firstly explore the issues with biology teaching that I have identified based on my experiences of teaching the subject and related to relevant literature. I will then explore a number of concerns identified in recent literature on biology education. I also explore the wider concerns about teaching science in general before focusing on the issue of subject identity and status in biology. I finish the chapter by considering how some of these issues might impact on beginning teachers of biology.

1.2 Is there a problem with biology education?

In this section I consider the wider context for biology education. My involvement with biology education spans about 30 years and for many of those years I was a secondary science teacher in a large comprehensive school. Among other, changing, responsibilities a constant was the responsibility for A-level biology teaching within the school. Since 2008 my involvement has been in Initial Teacher Education at a university. During this time, I have been aware of several tacit understandings (Berger & Luckmann, 1966) within the field. In the secondary teaching context, there appeared to be two perceptions evident in the way some colleagues spoke about biology in relation to the other sciences and in relevant biology education literature. Firstly, that biology is an 'easy' and therefore popular choice of science (Bevins et al., 2005, McComas, 2007), there are no issues with student uptake at post 16 and that students are achieving appropriately satisfactory grades in the subject. The second perspective was that biology is the trivial science, not really scientific compared to the physical sciences and that there is a gender

bias, with fewer boys choosing to take the subject post 16 (Subramanian, 2014). Another issue raised in the literature was the idea that biology is actually a wide ranging and diverse collection of subjects. This is significant when considering pupils' perceptions of what biology as a subject is actually about and it also has potential implications for the expertise of the teachers teach the subject at school as they are unlikely to be experts in all aspects of the curriculum (Biosciences Federation, 2005).

Moving into initial teacher training at a university, I became aware of some similarly taken-for-granted elements of the professional discourse. Firstly, that as it appeared that there were no issues with the recruitment and retention of biology teachers, compared to the recruitment and retention of teachers of the physical sciences, there were fewer incentives aimed at recruiting pre-service biology teachers. From September 2012 there was a government initiative to attract teachers of Science Technology and Mathematics (STEM subjects) and Modern Foreign Languages involving the payment of training bursaries that were initially based on degree classification. The bursary incentives for training to teach biology did not match those of chemistry and physics. In 2017 - 2018 Physics and chemistry carried an upper limit bursary payment of £30 000 and £25 000 respectively with Biology having an upper limit of £15 000. In 2018 there was a period of parity with all three sciences getting a bursary award of £26 000. However, for the cohort that will start their PGCEs in 2020, physics and chemistry specialists will receive an additional £6 000 early career payment (DFE, 201a7, 2018, 2020). The Institute of Physics and the Royal Society of Chemistry also offer a scholarship in place of the bursary, carrying a slightly higher payment and considerable status. To date biology does not have such a scholarship. So, although at the time of writing most subjects, and particularly

STEM subjects, are experiencing a recruitment crisis in teacher education, recent data show that there is an over recruitment of biology specialists compared to targets and there has been a return to the unequal financial incentive of previous years (DFE, 2019a). As one of my participants noted:

> *We always thought … biology's really good … and then to see other science teachers kind of discrediting it so, I mean, that were a bit random but … I think that's, kind of, stuck out … but then the Government doesn't help by making the biology bursaries less than… so why am I on a lot less than my … colleague who's doing physics even though we're putting the exact same amount of hours.*
>
> (Dan, Interview 2)

The second issue, and one that is also alluded to in the excerpt above, is that from my experience, some beginning teachers within the physical sciences disciplines, consider biology to be the science of lower status. This was illustrated while recruiting to the PGCE Science course, when, in response to a standard question about subject strengths and weaknesses, an applicant with a good degree in Natural Sciences from Cambridge University described her frustration with biology as a subject because she felt that there was nothing to understand, just a collection of facts to memorise. I had also heard beginning teachers voice similar sentiments; biology is a subject that involves recalling facts and, more worryingly, that A-level does not really involve experimental or investigative work other than required assessment activities. Interestingly the Biosciences Federation (2005, p. 2) offer the following definition of biology as *'A family of methods and disciplines grouped around the investigation of life processes and the interrelationship of living organisms.'* However, at the point of writing many of my students had not really experienced any

kind of investigative approach in the subject. These, often negative, perceptions of biology education have formed the basis of editorials and discussions in the practice and research literature over the past two decades and a series of articles have appeared in the professional journals that explore some of the issues. In 1998, as a precursor to the 2000 review of the science National Curriculum in England and Wales, academics associated with science education, including Michael Reiss, Robin Millar and Jonathan Osborne explored suitable models for a future science curriculum (Reiss et al., 1999). Reiss, in particular, analysed some of the claims for the successes in biology education. He acknowledged the healthy numbers of students opting to study the subject at A-level and beyond into higher education but also cautioned about the deeper story behind the figures (Reiss, 1998). His concerns centred on the fact that the percentage of the total number of students sitting A-level exams who opt to study biology was decreasing. He also claimed that many pupils both enter and leave schools with less understanding of general biology, pointing in particular to less awareness of natural history than in previous generations, but offers only personal anecdotal evidence as a biology educator himself to support this claim. Other concerns identified related to the recruitment and retention of 'well qualified' (Reiss, 1998, p. 20) teachers. Reiss discussed a series of recommendations for the 2000 science curriculum review; these included an emphasis on increased teacher and student autonomy, both in choice of content and context, more work with living organisms and greater emphasis on environmental education. He also, in common with Millar and Osborne (1998), suggested an increasing emphasis on bioethics and 'scientific literacy', an understanding of the science that individuals might encounter in day-to-day life. A notable response to the recommendations from agencies developing specifications for GCSE exams came in

the form of Twenty First Century Science, a suite of GCSE qualifications developed by the Nuffield Foundation which acted on many of the recommendations, but which found themselves at the centre of 'dumbing down' controversies in the media (Perks, 2006).

In 2005 the Biosciences Federation, a group consisting of university academics, representatives from schools and colleges and bioscience research, was founded in order to '*create a single authority within the life sciences that science and education decision makers can consult …'* (2005, p. i). The group was chaired by Michael Reiss and produced the report 'Enthusing the Next Generation.' Evidence for the report was obtained through a series of consultation questionnaires to a wide range of stakeholder groups such as the Department for Education, assessment and curriculum standards bodies, research councils and those involved in education at all levels. The introduction to the report includes the following statement:

> *recent years have seen a disturbing decline in numbers choosing to study physical sciences, and a move away from* **core** *bioscience disciplines*
> (Biosciences Federation, 2005, p. I, author's emphasis)

The report then outlines several grounds for concern, noting that although the study of biosciences is popular, and that numbers in higher education are being maintained, there is a wide range of subjects that fall into the biosciences category of subjects, including psychology, sports science, and forensic science, and that some 'core' subjects, identified in the report as pharmacology, biochemistry, and microbiology, are not being chosen. The report also challenges the 2005 Higher Education Funding Council for England (HEFCE) report on strategically important

and vulnerable subjects which suggests that because overall numbers of bioscience students are being maintained in universities there is no problem to address.

Strong recommendation came from the consultation that the biology curriculum should concentrate on key principles rather than excessive detail and key concerns were expressed about the disjointed, modular nature of the subject at secondary school and the lack of time for deeper learning. Concerns for the teaching and learning of biosciences at undergraduate level were that current undergraduate assessment procedures appeared to lead to short-term superficial learning rather than a deeper understanding, a concern echoed in more recent articles and editorials. In 2007, in an editorial for the Journal of Biology Education, Tunnicliffe and Ueckert considered the 'great dilemma' in biology education, '*How do we deliver the crowded syllabus and desired exam results, while truly educating students?'* (p. 51). The authors, drawing on research by the National Association of Biology Teachers, a US professional association that has no equivalent in the UK, suggested that many students are learning phrases referred to a 'biology bytes' (p. 51) rather than developing a deep understanding of concepts and that teachers felt that the assessment driven climate was making it impossible to teach the subject holistically. They felt that a deep understanding of key biological ideas was lacking.

In 2010, writing an editorial for the same journal Page and Reiss issued a similar call to account in biology education (Page & Reiss, 2010). They noted that at this point there was very little research being carried out into biology education in the UK and that biology education lacked the same drivers for improvement as other Science, Technology, Engineering and Mathematics (STEM) subjects such as chemistry and physics. In the UK, the perception was that biology was successful, both in attracting students to participate and in attainment, and so did not need to attract the same

funding and attention from the policy makers. They also noted that the market driven nature of the examining bodies meant that less 'popular' topics were left out of specifications although there is no detail in the article about what these less popular topics may be, the assumption is that the authors were referring to the more difficult and traditional aspects of biology such as botany and zoology, which have disappeared from post-16 specifications over the years. They also highlighted a reduction in activities that may be hard to assess such as field work investigations. This was an aspect of biology that I had noticed being marginalised as an opportunity to formally demonstrate practical skills at A-level during my time as a secondary teacher, although it is interesting to note that a field work practical now appears as part of the Required Practical activities for both GCSE and A-level biology since the 2015 examination reforms (Ofqual, 2015). The call by Page and Reiss to look behind the apparently healthy numbers of students and teachers and consider the quality of education in biology still feels relevant a decade on.

A review of wider research literature around biology education reveals similar prevalent conceptions. Subramaniam (2014) sets out four key assumptions that are found in a number of papers and these echo elements of the professional discourse that I noted at the beginning of this section:

1. That biology is an easy science subject involving the rote learning of facts, rather than a subject that builds conceptual understanding (McComas, 2007).
2. That biology teaching depends on transmission / lecture formats of instruction.
3. Dissections epitomise the practical work carried out in biology lessons.
4. That there is an over reliance on the use of work sheets as a pedagogical approach (Tunnicliffe & Ueckert, 2007).

Subramaniam's research also identified concerns around limited exposure to pedagogical approaches such as fieldwork, investigative activities and hands-on practical activities, a concern raised in a number of articles and editorials previously (Reiss, 1998, Tunnicliffe & Ueckert, 2007, Page & Reiss, 2010). More recently though, Jenkins (2016) reflected on the evolution of biology as a school subject and was cautiously optimistic about both the developments and the progress that has been made, citing the reforming influence of projects funded by the Nuffield Foundation, the School's Council for the Curriculum and Examinations and the Scottish Education Department who have sought to reform both the content of the biology curriculum and the way it was approached in schools. He cited the success of the subject noting that in 2015 A-level biology ranked third, below English and mathematics, in terms of the total percentage of UK examination entries (Jenkins, 2016).

As is evident from this brief review of relevant literature, although key concerns are common there are also some contradictions and tensions. On the one hand there is a criticism of the curricular content in that it is outdated and too detailed, but on the other hand there is a concern that 'core' biology topics are being lost. There are recommendations for the content to focus on developing pupils' understanding of the biological ideas that they might need to understand as citizens but also concerns about students' lack of deep understanding of key concepts. At the time of writing however, the GCSE reforms which began in 2011 have introduced a school biology course that is seen as increasingly mathematical, has more emphasis on experimental skills and application of knowledge and is considered more conceptually demanding than previous GCSE specifications (Jenkins, 2016) perhaps addressing some of the concerns about rigour of content.

There are also ongoing concerns about biology as a subject at higher education (HE) level. Kelly-Laubscher and Luckett (2016) note concerns around biology students' successful transition into the study of biology in HE. They suggest that students perform well at secondary level and achieve 'formal access' to biological concepts at university but that many students do not have 'epistemological access', the access to the deeper understanding required at this level. My experience suggests that this potential mismatch between 'formal access' and 'epistemological access' is not just limited to the transition from secondary school to higher education but can exist at the transition from undergraduate courses to a Post Graduate Certificate in Education (PGCE) course, even if the student's degree is biology based. In my own experience I have found that having appropriate qualifications for a biology PGCE course does not always mean that an individual has a deep understanding of concepts that would enable them to frame clear explanations and be able to plan teaching activities. This raises challenges for teacher educators around the development of beginning teachers' pedagogical content knowledge (Kind, 2009) such as uncovering misconceptions and enabling students to develop a deep understanding of key ideas such as the cell concept (Harlen, 2010).

1.3 Wider concerns about science

Although one of the concerns about biology education compared to the other sciences has been the lack of drivers for research into subject specific pedagogy, the literature suggests that there are a number of ongoing concerns about secondary school science education in general and that some of these issues relate directly to the concerns about biology discussed in the previous section. Osborne (2007) argues the case that science education globally is based on taken for granted norms that have never been challenged. Over many years Osborne has considered the

tension between science education for the minority of pupils who intend to continue to study science further and science education for the majority of pupils who he sees as 'critical consumers of science knowledge' as a problem. He has long been an advocate for a science education based on the concept of 'scientific literacy.' 'Scientific literacy' is a term that is debated somewhat in the literature but its use here is intended to refer to the knowledge and scientific understanding that will enable pupils to make informed judgments regarding social and ethical issues relating to the science that they will encounter in their daily lives (Millar & Osborne, 1998). He argues that all pupils are *not* best served by one curriculum. Because of this stance he considers one of the key issues with science education to be that many programmes of study across the world are content heavy and emphasise recall of facts. He echoes concerns that I identify in my approach to biology pedagogy with pre-service teachers, that many science programmes have a foundational approach to scientific knowledge and attempt to build the pupils' body of knowledge in a detailed, piece by piece approach. The focus is on learning detail, often at the expense of a more holistic view of concepts in science. He also raises issues with the need to cover such a range of content in the name of a broad and balanced curriculum (Osborne, 2007). In my opinion this content heavy and fragmented approach to the subject is particularly notable in the secondary biology programme of study in schools. The consequence of these issues, along with a school culture based on high stakes testing, is to encourage pedagogy based on transmission and recall (Osborne, 2007, Berliner, 2011). Even the recent Initial Teacher Training (ITT) Core Content Framework (DFE, 2019b) emphasises the need to teach beginning teachers about recall strategies and working memory and refers to techniques for memorising content a number of times. There would seem to be

tensions between the emphasis on memory and performance and other work that considers the more creative and affective dimensions of teaching the subject such as ‘maintaining curiosity’ and pupil engagement (Ofsted, 2013, Rotheram, 2014).

The use of practical work in science is also identified as a problematic area. It is perceived by many pupils and teachers as both enjoyable and effective in improving learning but there are concerns that in many cases practical work may contribute little to the understanding of science concepts (Abrahams & Millar, 2008). Abrahams and Millar argued that in many cases there was a mismatch between the teacher’s planned learning outcomes and the learning that actually occurred during practical work. Their study suggested that pupils can often do what is asked of them in a practical and collect relevant results and data but that they may not achieve a deeper understanding from the activity, referred to in some studies as ‘recipe following’ practical work (Abrahams & Millar, 2008, Phillip & Taber, 2016). With regard to the recent GCSE and A-level reforms introducing ‘Required Practicals’ for science in England (Ofqual, 2015) a concern among the teachers that I spoke to in this study was around the repeated rehearsal of certain practical activities to no end other than to ensure that pupils could answer exam questions with an emphasis on certain practical activities at the expense of more investigative approaches to practical work. These issues are a concern in biology but also in science education more widely given that the research suggests that classrooms that facilitate independent scientific thinking, inquiry approaches and pedagogies that support deep understanding of key concepts enhance both pupil achievement and pupil engagement (Nolan, 2003, Bevins & Price, 2014).

1.4 Subject specialism and status

Returning to biology specifically, one of the recurring issues in the existing literature surrounding biology education is that of the wide range of subjects that can be actually identified as ‘biology.’ Reiss (1998) both comments on the 'reasonableness' of widening the definition of biological science and expresses a concern that in higher education a wide range of subjects is included as part of biology degrees, arguing that this gives a false indication of healthy numbers because 'core' subjects such as biochemistry, energy transfer systems and detailed cell biology are not being selected. The Biosciences Federation Report (2005) also cautions curriculum developers on the loss of 'core' biological topics at both A-level and in higher education but some of the authors have previously been critical of the content of secondary biology syllabi as being irrelevant and uninspiring (Tunnicliffe & Ueckert, 2007). It is interesting to examine the number of undergraduate degree courses identified for the three sciences by the National Student Survey Discipline Reports (HEA, 2011a, HEA, 2011b): 146 courses are listed in the biological science report, including subjects that fit with the Bioscience Federation's description of 'core' such as biochemistry and microbiology, very traditional biology subjects such as zoology and botany and courses that cover applied contexts such as forestry and food and beverages. In contrast chemistry and physics are combined into a single report on the 'physical sciences'. Chemistry contains 23 courses in its subject list and physics identifies 27 courses including those related to astronomy. The list reveals a much smaller proportion of applied courses, and these include examples such as 'Medical Physics' and 'Petrochemical Chemistry'.

This would appear to be an example of the regionalisation of a subject (Bernstein, 1996), the organisation of subjects into larger related blocks potentially more

influenced by external factors such as market forces (Moore, 2001). Although this regionalisation would appear to be a trend in higher education, in secondary schools there was a move towards separate sciences in response to the significance of the English Baccalaureate as a performance indicator (Long & Denechi, 2019). This raises a question about the implications of this regionalisation in biology at university for teacher education. Certainly, it potentially increases the number of candidates eligible to apply for a place on a PGCE biology course and it also increases the possible specialist subject experiences that candidates might have on entering the course, but it is also possible that this is affecting the subject expertise of prospective biology teachers in some way that may not be happening with prospective teachers of the physical sciences. As Jenkins (2016) asks, if 'biology' is actually an umbrella term for a large number of disciplines how does this fit with the subject knowledge demands of the secondary biology curriculum and how might we best train biology teachers given this potential for diverse subject backgrounds? Is it possible that the combined effect of the increasing regionalisation of biological sciences in higher education, with its potential to produce ‘biology’ graduates with a widely varied range of experience and subject expertise, plus the influence of the performativity culture in schools, is having a profound effect on the professional and academic knowledge of those who teach biology? Individuals entering the teaching profession may find their professional knowledge development challenged, not just by the audit culture (Beck & Young, 2010) but by their own position within the discipline of biology itself. Given the detailed and often quite traditional content of the secondary biology curriculum (Reiss & Tunnicliffe, 2001) and the emphasis on factual information required by students in order to successfully pass exams, it could be that in biology, of all the sciences, there is an increased pressure to adopt a pedagogy that focuses on

surface and strategic learning rather than one that develops deep, conceptual understanding (Tunnicliffe & Ueckert, 2007).

The uptake and achievements at A-level have also been used in discussions about the status of biology compared to the other sciences. In an analysis of inter-subject comparability between A-level subjects Ofqual compared the distribution of A-level grades for students entering with a GCSE grade A in the subject rather than the overall grade distribution. Looking at a comparison of the three science subjects: 59% of students with a GCSE grade A obtained the top 3 grades at A-level (grades B – A*), 50% of the students in chemistry and 46% of the students in physics. The report tentatively suggests that this could be used to indicate the relative 'difficulty' of an A-level subject, the implication being that biology is the easier of the three science A-levels. However, the report itself does acknowledge criticism of the methods of statistical analysis which appear to give conflicting results if different sub-groups are analysed. It also raises concerns that multiple factors may be at play that are difficult to control or isolate (DFE, 2017b).

1.5 The challenges for beginning biology teachers

Having considered some of the issues in biology education, in this section I explore how some of these issues might impact on beginning teachers of biology. In considering the factors that influence the beliefs of science teachers, Mulhall and Gunstone (2012) explore beliefs in physics teachers. Theirs was a qualitative study focused on two teacher perspectives; those teachers who taught in a traditional way, defined in this case as emphasising facts and definitions, who also had the belief that there was little that was problematic about the subject and those teachers who taught for conceptual change in the students. The views of the teachers involved

were explored in extended interviews and inferred from classroom observations. The findings suggested that beliefs are often tacit and difficult to move and that early exposure to the study of the philosophy and history of scientific thought could have an effect. A second, earlier study by Smith (2005) examined the differences in the life experiences of two primary science teachers and explored how these influenced their classroom practice. Again, the data were collected using questionnaires, interviews, and classroom observations. The two teachers who were the focus of the case study were selected to ensure similarity in respect to their formal in-school experiences. Although limited to a small number of participants the study suggested that early out-of-school experiences are potentially more powerful in influencing teachers' beliefs about teaching and learning science. This may be particularly important in relation to informal experiences that relate to the natural world, particularly if, as has been argued, young children are becoming isolated from the environment in a way they have not previously been, suggesting a growing situation of 'nature deficit' (Louv, 2005).

There are potentially many factors influencing the individuals that choose to become biology teachers. As discussed, the broad nature of the subject in higher education can leave graduates with very different experiences and expertise from those required in the narrower subject domains in schools more frequently than graduates in the physical sciences. For example, PGCE biology students may have degrees that specialise in marine biology or forest ecology and management, specialisms that have limited or no equivalents in the secondary curriculum. In addition to this, my experience of beginning science teachers suggests that a perception that biology has a lower status than the physical sciences may discourage high achieving bioscience graduates from considering teaching as a profession. Both these issues

have the potential to contribute negatively to the subject identity of biology teachers. Results are the current driver within schools, and this performativity culture and the lack of clear subject identity could contribute to the development of a strategic learning pedagogy; one which can remain unchallenged as it is apparently successful, producing acceptable achievements in examinations and healthy uptake of the subject at post-16. Given that beginning teachers currently participate in a teacher education model that involves a large amount of time in school it is possible that they are working alongside other biology teachers who model this approach, leading to generations of biology educators who have known no other approach. Unlike the Royal Society for Chemistry and the Institute of Physics, the Society for Biology is itself made up of many disparate groups and the emphasis appears to be on bioscience research and concept support for teachers rather than a consideration of effective pedagogy, so biology teaching practices currently feel less challenged and less supported by a wider expert body. In addition to this, beginning biology teachers face challenges in terms of the nature of the subject itself. As discussed earlier there is a large amount of content and there are sometimes issues with the organisation of that content in the school curriculum (McComas, 2015). Biology concepts move from the concrete to the symbolic depending on the concepts being addressed and this has an impact on the engagement and interest of both teachers and pupils and their perceptions of it as a problematic subject (Bahar et al., 1999) something that I will discuss further in Chapter 5.

Attitudes and beliefs about their subject contribute to a biology teacher's professional knowledge and their classroom decisions, which I will explore further in the next chapter and although there has been much research on teacher knowledge and learning, including that of science teachers (Helms, 1998, Varelas et al., 2012,

Avraamindou, 2014) there has been little that has focused on a secondary biology subject perspective. There is, therefore, a need for research which explores teachers' perceptions of the factors that contribute to their pedagogical approach in terms of their *subject*. This study therefore aimed to gain insights into teachers' expressed perceptions of their subject and some of the factors that they felt were influencing their pedagogical decisions. This is needed to inform the way that biology specific pedagogy is introduced to beginning teachers and to consider the support that they need while in school, including the implications for support in the new Early Career Framework (DFE, 2019c)

1.6 Chapter Summary

I opened this chapter with the question 'Is there a problem with biology education?' Based on this review of relevant literature, it would seem that this could be the case. There are clearly some concerns about the pedagogy of biology with examples of strategic teaching and rote learning as a way to achieve success, certainly at GCSE level. There also appear to be concerns around the lack of meaningful practical work in the subject, particularly at A-level. These concerns include the challenge of teaching a large amount of, often fragmented, content in a way that is both relevant and meaningful to all pupils and that also fosters deep understanding. The huge range of topics and concepts that come under the heading of biology may also have implications for the expertise of beginning teachers and the engagement of pupils. Biology appears to have healthy numbers of pupils studying it at A-level and undergraduate level and there are healthy numbers of biology specialists applying for Initial Teacher Education courses. However, there is evidence that achievement in biology does not always reflect a deep understanding of concepts. Some of these issues are challenges for science education in general, but some of them, such as

perceptions of the status of the subject and the apparent success of pedagogy based on recall rather than conceptual change, are more specific to biology. Biology education does not seem to have the same level of pedagogical support from subject specific professional bodies that is seen in chemistry and physics. There would definitely appear to be a perception that biology is the easy option and the least 'scientific' of the sciences. Finally, there would seem to be a misunderstanding of the fundamental interconnected nature of science in some of the debates around the status of the subject. Biology has often been the lone science taken by students at A-level to broaden their qualification profile but, in order to understand many of the concepts that are taught at A-level, students need a good understanding of chemistry. If students are to meet the requirements of the 2015 curriculum reform, they will need an understanding of underlying scientific principles from across the disciplines. The application of key ideas to different contexts now has a much larger emphasis in examination questions. There is also an increased requirement for students to be confident with mathematical skills. The concern from a teacher education perspective is that some of the issues identified are perpetuated as beginning teachers come through the education system. However, there is clearly inspirational biology teaching practice happening so one of the aims of this study is to find out what teachers believe about the teaching of their subject, what is influencing their classroom decisions and how they feel they are able to act on those beliefs in school. In the next chapter I examine the concept of teacher knowledge as one of the theoretical frameworks that will be relevant to this study.

Chapter 2: teacher Knowledge

2.1 Introduction

The title of my study refers to biology teachers' 'pedagogical thinking.' In this chapter I look at the relationship between beliefs and teacher knowledge. I consider how teacher knowledge might be categorised and described. Finally, I consider the models of teacher knowledge that have informed this thesis and explain how these relate to my term, pedagogical thinking.

2.2 How do teacher beliefs relate to teacher knowledge?

It is argued that teachers' beliefs are one of the best indicators of decisions made in the classroom (Helms, 1998, Pajares ,1992). However, it is not easy to find clear definitions of the term 'belief'.' Pajares in an attempt to 'clean up a messy construct' (1992, p. 307) tried to clarify a conceptualisation of belief and claimed belief to be potentially the single most important construct in educational research, particularly when being considered in the context of teacher education and support for pre-service teachers. Drawing on several research studies and frameworks he arrives at a list of fundamental assumptions that can be made when researching teacher beliefs. Among them: beliefs are formed early and tend to persist; the belief system helps individuals to define and understand the world and themselves; although knowledge and belief are entwined, belief can be considered as the filter through which new knowledge is interpreted; beliefs must be understood in terms of their connections to one another and to central beliefs, referred to by psychologists as attitudes and values; and most importantly, beliefs are instrumental in defining behaviour. Wallace (2013) goes as far as suggesting that beliefs are more influential than formal academic knowledge (see section 2.3) in the classroom decisions made

by science teachers. An exploration of conceptualisations about belief can feel like variations on a list of characteristics of the concept, however a number of more recent studies reference the work of Pajares as their framework (Hermans et al., 2008, Mansour, 2009, Wallace, 2013,) and also attempt to distinguish between belief and knowledge, explaining that beliefs are based on evaluation and judgement whereas knowledge can be judged to have some degree of external objective 'truth'. Ueda and Isozaki (2016) claim that both knowledge and beliefs originate from experience, and that both are cognitive structures, but the distinction is that beliefs also consist of an emotional structure. In earlier studies science teacher beliefs about teaching and learning were sometimes conceptualised as a dichotomy between transmission or constructivist approaches to teaching (Mulhall & Gunstone, 2012). However, Mansour (2009) argues that this is too simplistic. Mansour summarises earlier studies that look at the sources of teacher beliefs. He, like many others, argues that teachers' beliefs develop over their lifetime and are influenced by a wide variety of factors including people and experiences. He cites Dewey and suggests that personal experience is a key source for informing educational practice. Mansour then goes on to identify two separate types: formal experiences such as schooling, further education and continuing professional development; and informal experiences in teachers' day to day lives, past or present that might impact on their beliefs and knowledge. Ueda and Isozaki (2016) define a science teacher's beliefs as 'individual thoughts based on experience and prior knowledge' (p. 37).

One of the key discussions in the literature has been around how knowledge and beliefs interact in teachers and I include a simple diagram adapted from Snider and Roehl and in turn influenced by the work of Pajares (see Figure 2.1).

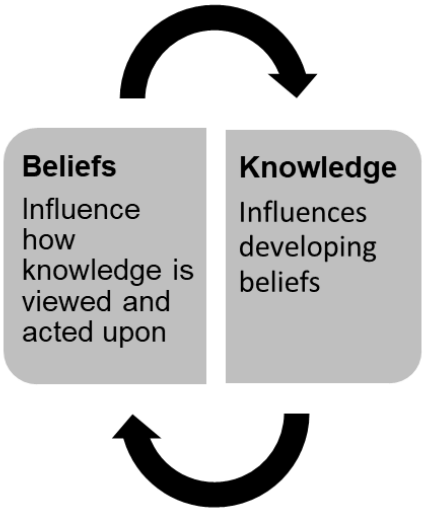


Figure 2.1 The link between teacher beliefs and teacher knowledge (Adapted from Pajares, 1992, Snider & Roehl, 2007)

In this study I take the view that beliefs about biology teaching originate in past experiences and have an emotional dimension. I understand beliefs to be the lens through which formal teacher knowledge and personal practical teacher knowledge are viewed and that they are important in informing classroom decisions. Beliefs encompass what an individual personally values about the process of teaching and learning in biology and informs their image of the biology teacher that they want to become.

2.3 Categories of teacher knowledge

As illustrated by Figure 2.1 it is argued that teacher knowledge is entwined with belief, that developing knowledge influences belief and that both knowledge and beliefs impact on classroom decisions (Pajares, 1992, Snider & Roehl, 2007). Teacher knowledge is considered to be a 'complex tapestry' of factors (Adoniou, 2015) and there are a number of different models of teacher knowledge to be found in the literature. I will begin with the basic premise that teacher knowledge can be

defined as ‘a teacher’s understanding of how to help students understand … specific subject matter’ (Magnusson et al., 1999, p. 96). I do not intend to discuss all models of teacher knowledge but want to draw on the models that have influenced my thinking in this study and explain how I see their relationship to one another.

Cochran-Smith and Lyttle (1999) described three broad approaches to teacher learning which they referred to as ‘knowledges’, these were ‘knowledge for practice’ which referred to the systematic knowledge generated by expert researchers and provided to the teacher, ‘knowledge in practice’ which referred to the knowledge generated by expert teachers through their own experiences, and ‘knowledge of practice’ which is generated when teachers intentionally research their own classroom practice. These classifications of teacher knowledge are given different names but essentially are echoed in a number of sources (Shulman, 1986, Magnusson et al., 1999, Guerrero, 2005). Brant (2006), in a review of models of teacher knowledge, also acknowledges a distinction between formal and practical knowledge in a similar way to Cochran-Smith and Lyttle but argues that the literature suggests an additional category of knowledge which they call ‘prescriptive knowledge’, which is seen as a teacher’s knowledge of institutional policies. Brant describes this as knowing what *should* or *ought* to happen. This knowledge may well be accepted unquestioningly by teachers but is filtered through their own beliefs in its interpretation (Brant, 2006). It is clear that these models of teacher knowledge overlap but for the purposes of this study I intend to consider teacher knowledge categorised in terms of formal knowledge, personal practical knowledge, and personal practical theory, which I see as approximately corresponding to the knowledges described by Cochran-Smith and Lyttle (1999). Below I explore each of these in turn.

2.4 Teachers' formal knowledge

Shulman (1986) is credited with starting an interest in research into teacher knowledge and developing the theoretical construction of Pedagogical Content Knowledge (PCK) (Mecoli, 2013). Most of Shulman's categories of teacher knowledge are self-explanatory but I want to give some details on PCK because this category of knowledge could be argued to straddle both formal knowledge and personal practical knowledge. PCK was considered by Shulman to be a combination of subject or content knowledge and general pedagogical knowledge. PCK allows the teacher to identify and utilise the most effective ways of representing key concepts in a subject and to understand what might make the academic subject easy or difficult for pupils to understand (Shulman, 1986). Shulman proposed seven categories of teacher knowledge including PCK: subject content knowledge, general pedagogical knowledge, pedagogical content knowledge, knowledge of the curriculum, knowledge of learners and their characteristics, knowledge of educational contexts and knowledge of educational aims and values. This model describes categories of teacher knowledge that I would characterise as formal, propositional and codifiable, it represents knowledge for practice (Cochran-Smith & Lytle, 1999, Bertram & Christiansen, 2012) although it has been argued by some researchers that PCK is a more ambiguous category of knowledge and could be considered to be a skill rather than a knowledge base (Fernandez, 2014, Gess Newsome et al., 2017). In a study exploring PCK in science teachers Gess Newsome et al. (2017) posited that PCK itself consisted of internal constructs and suggested that it could be broken down into the identification of connections within and between concepts in science and an understanding of how to link teaching strategies to pupil learning, including context specific knowledge about variations in

pupils and how this might impact pedagogical decisions. However, looking at how the researchers elaborate on the concept of PCK I would argue that as a knowledge category it falls in the domain of formal teacher knowledge, particularly if you consider that knowledge of variations in pupils is often a combination of pedagogical approaches for different pupil needs and knowledge about applying pupil data when lesson planning, aspects of which are covered in initial teacher education programmes and formal ongoing professional development.

2.5 Teachers' personal practical knowledge

Several researchers have argued that the formal codified knowledge that teachers have is only one aspect of teacher knowledge and that insight and intuition contribute significantly to how this knowledge is used (Fenstermacher, 1994, Connelly et al., 1997, Brant, 2006). This type of knowledge is idiosyncratic, experiential and usually tacit (Guerrero, 2005) and is given a variety of names in the literature including 'craft knowledge' (Hubermans, 1983 cited in Brant, 2006) 'wisdom of practice' (Shulman, 1986) and the term that I will be using in this study 'personal practical knowledge' (Clandinin & Connelly, 1994).

It is widely agreed in the relevant literature that teachers rely on the development of *practical* knowledge (Lortie, 1975, Elbaz, 1981, Clandinin & Connelly, 1986) defined as the knowledge that is gained through accumulated experience and used in a teacher's own practice (van Driel et al., 2001). This knowledge is a combination of procedural knowledge, as suggested above, beliefs and personal motives and enthusiasms. Fenstermacher (1994) refers to it as the knowledge *of* teachers rather than knowledge for teachers which appears to be analogous to Cochran-Smith and Lytle's 'knowledge in practice' (1999). It is developed through experience and

reflection on experience and is personal, contextual in that it is defined in the specific school context, mainly tacit and related to the subject being taught (Meijer, Verloop, & Beijaard, 2001). Guerrero (2005) suggests the name ‘case knowledge’ after Shulman (1986) to describe the mental models of classroom life that are developed through classroom experience and drawn on by experienced teachers in their day-to-day work.

A key influence on this study was the concept of practical knowledge as outlined by Clandinin and Connelly (1986). Their work originates in ideas from Dewey (1938) who argued that personal experience leads to knowledge that is constructed and reconstructed over time. They refer to this tacit knowledge as ‘personal practical knowledge’ and suggested a methodology using teacher narratives as a way of exploring teachers’ personal sense of understanding the classroom and teaching. They argue that practical knowledge is not just about knowing how to apply theories of learning, knowledge of the curriculum and knowledge of how pupils might behave and respond but involves a combination of theoretical and practical knowledge influenced by recollections of previous experience and beliefs in the specific teaching context (Clandinin & Connelly, 1986). The ‘personal’ aspect of personal practical knowledge refers to the conception that this knowledge arises from experiences and actions that have had an affective content for individual teachers (Clandinin, 1985) and recognises the central position of the teacher themselves in the generation of this knowledge (Verloop et al., 2001). The ‘knowledge’ aspect of Clandinin and Connelly’s term for tacit teacher knowledge refers to convictions, both conscious and unconscious, that have arisen from personal and professional experiences which are then expressed in practice (Clandinin, 1985, Clandinin & Connelly, 1986). This type of knowledge is revealed through the classroom decisions that teachers make and

through their stories about their lives as teachers (Clandinin & Connelly, 1994). This experiential knowledge is not objective and independent but is the sum of an individual teacher's experience. It influences every aspect of teaching including relationships with pupils, their interpretation of the academic subject being taught and its importance to pupils' lives and acts as the lens through ideas from formal knowledge are interpreted (Connelly et al., 1997). A number of researchers have argued for teachers' practical knowledge to be given the same status as formal knowledge as it is deep, sensitive and highly contextualised (Elbaz, 1981, Clandinin, 1985, Clandinin & Connelly, 1986).

The literature cited above suggests that reflection is an important aspect in personal practical knowledge development. Again, this builds on Dewey's (1938) suggestion that reflection can be considered as a form of thinking inspired by experiences of disordered situations in order to construct and deconstruct an understanding of that experience. Reflection on a teacher's own practice is argued to be the 'essence' of being a professional in a classroom environment (Feucht et al., 2017). In the next section I explore how a combination of personal practical knowledge and reflection lead to teachers' professional theory.

2.6 Teachers' professional theory

Cochran-Smith and Lyttle (1999) identified a category of teacher knowledge that they referred to as 'knowledge of practice' to describe the knowledge generated when teachers purposefully investigate formal knowledge within the context of their own classrooms. They argued that this investigative approach required reflection on classroom practices and that this reflection enhanced a teacher's personal practical knowledge, making that knowledge explicit and articulated.

Mannikko and Husu (2019) also suggest a refinement to the concept of personal practical knowledge. They use the term ‘adaptive expertise’ to represent the concept that teacher practical knowledge can be further developed through reflection so that practical knowledge is theorised, and theoretical knowledge is interpreted through practice. They suggest that with specific reflection teachers develop beliefs and knowledge through their teaching experience that can become overt and examinable. Teachers’ personal practical knowledge is transformed into teacher professional theory. Feucht et al. (2017), however, argue that reflection does not always result in a change to practice but can focus on incidents and strategies. They suggest that to make reflection for action effective there is therefore a need to focus on reflexivity. Reflexivity in this context suggests a deep inward gaze that allows a teacher to examine their interactions and carry out a constant analysis of their own suppositions. In this way reflexivity can lead to action and transform practice. (Hofer, 2017). Feucht et al. summarise this as:

> *Reflection becomes reflexivity when informed and intentional internal dialogue leads to changes in educational practices, expectations, and beliefs.* (Feucht et al., 2017, p. 234)

The concept of teacher professional theory suggests something deeper than just a knowledge of personal strengths and weaknesses (Elbaz, 1981) or a reflection on shortcomings or successes in the classroom and so appears to require the reflexivity being described in relevant literature (Feucht et al., 2017, Hofer, 2017)

2.7 Pedagogical Thinking

From the literature it would seem that the different categories of teacher knowledge described are not necessarily easily separated from one another. The lines between

knowledge use and knowledge generation can be blurred (Cochran-Smith & Lyttle, 1999). Personal practical knowledge includes the teacher's interpretations and application of formal knowledge and theory in their specific contexts combined with experiential knowledge to address present issues in the classroom. I also believe that this personal practical knowledge includes elements of 'case knowledge', (Guerrero, 2005) which I understand as highly contextualised mental models of how specific approaches will relate to specific pupils and combinations of pupils. This combination of formal codified knowledge, considered through the lens of beliefs which are also entwined with personal practical knowledge, and case knowledge informs a teacher's classroom decisions. It is this combination of beliefs and knowledges that I refer to when I use the term 'pedagogical thinking.' I conceptualise pedagogical thinking as the mental process that contributes to a teacher's classroom decision making. This thinking includes conscious and deliberate thinking as well as more intuitive approaches (Kansanen, 1991). It allows the teacher to use their personal practical knowledge and draw on case knowledge to consider how to apply their formal knowledge. All these aspects are underpinned by beliefs and may include unconscious bias and prejudices about how to teach biology to a particular pupil or pupils. (Kansanen, 1991). A teacher's pedagogical thinking informs their planning for action, but this will always be mediated by their ability to act on that thinking which may be constrained by physical resources, time, and other contextual considerations. Reflexive thinking about these knowledges can enable teachers to articulate not just what they think should be important in their classroom approaches but why they feel it is important.

2.8 Chapter summary

In this chapter I have examined some of the models of teacher knowledge and considered how that knowledge could be described and categorised. I use the term 'teachers' formal knowledge' to represent the codified knowledge *for* teachers that is 'received' in initial teacher education programmes and professional development. I include pedagogical content knowledge in this category of formal knowledge. I use the term 'teachers' personal practical knowledge' to represent the experiential often tacit knowledge that teachers generate in practice. 'Teachers' professional theory' is generated when teachers engage in reflexive thinking, a purposeful internal dialogue that allows them to consider how they are using these knowledge bases in their particular context. I refer to this interplay of formal knowledge, experiential knowledge and reflexive thinking that informs classroom decisions as 'pedagogical thinking.'

Chapter 3: Methodology

3.1 Introduction

As explored in the introduction, my research questions for this study were as follows:

1. What are biology teachers' expressed beliefs about teaching their subject?

2. What are biology teachers' perceptions of the way in which previous experiences with their subject have influenced their beliefs about teaching biology?

3. What are biology teachers' perceptions of how they can implement their beliefs in the classroom?

My study used the constructivist design of grounded theory developed by Charmaz (2000). The data generated were teachers' narratives about their experiences of becoming and being biology teachers obtained through a series of semi-structured interviews. I decided to focus on narrative data only rather than include observations of pedagogy for a number of reasons. Firstly, I felt that an approach involving classroom observations in the current climate had the potential to feel judgemental and a source of additional stress for participants. Secondly, I was interested in the participants' own perceptions of their role as a biology teacher rather than my perceptions of their classroom approaches, and finally I was aware of the possibility that local school contexts may actually act as barriers to a teacher fully implementing their vision for biology teaching. I felt that narratives would allow them to explore such factors. The design of the study combined elements of narrative inquiry and grounded theory, a choice that I explain in more detail in section 3.5.

This chapter details the methodology and design of my study. It begins with a discussion of the two key strands that underpinned my approach: the use of personal

stories as data and the grounded theory methodology. In the second part of the chapter, I give details of the methods used in the study including sampling and data collection and discuss ethical considerations. I conclude by outlining my approach to data analysis. I then follow this in Chapter 4 with a more detailed look at my process of analysis.

3.2 Personal Position

In order to contextualise the methodological choices that I made I begin by outlining the process which led me to develop my position in relation to the use of teacher narratives as data. This required a significant ontological shift for me as a researcher. In order to clarify my own understanding of the knowledge claims being made in studies that used narratives as data I found it useful to look at discussions of narrative as data in other contexts. These were, clinical education, particularly given that medicine is traditionally the field of firmly positivist approaches to research such as randomized controlled trials, and public administration research. Bleakley (2005) is an advocate of the use of narrative inquiry methods in clinical education, in particular the use of ‘synthesis’ or ‘thinking with stories’. He describes ‘capturing the voice’ of the person in order to generate empathy in the reader and argues that methods which use an individual’s stories as data provide insights into intellectual, spiritual, practical, emotional and relational aspects of that person’s situation although the methods may not produce conclusions or models to be tested. The main use of the knowledge gained is to engender reflection and resonance in the readers. In the context of public administration research, Ospina and Dodge (2005) contend that stories can make explicit the underlying taken-for-granted assumptions that people hold, and that the use of these methods can challenge those that focus on predicting and explaining but instead allow us to focus on interpretation.

One of the main outcomes of reading studies such as these (see Section 3.3 below for a more extended discussion) was a shift in my own thinking about the nature of data and research. I believe that I began this study influenced by my positivist background. Certainly, the language I was using initially suggested that my participants' stories would be a source of external information that I would 'discover' themes in, rather than a more mutual process of constructing meaning from the stories. At this point I want to give some brief background that informed my thinking about my ontological position. I am defining ontology according to Blaikie (cited in Mack, 2010) as the

> *study of claims and assumptions that are made about the nature of social reality, claims about what exists, what it looks like, what units make it up and how these units interact with one another. (p. 5)*

My personal ontological journey started upon reading the question: '*is social reality external to individuals - imposing itself on their consciousness from without - or is it the product of individual consciousness?'* (Burrell & Morgan, 1979 cited in Cohen et al., 2011, p. 5)

Cohen et al. (2011) contend that this question arises from the nominalist - realist debate. Is the social world a construction, created through language, or does it have an independent existence? Alvesson and Gergen (2009) identify three overlapping philosophies: positivism and post-positivism, social constructionism and critical realism. Positivism represents the dominant philosophy of the natural sciences in the last century. Positivism assumes that data exist 'out there,' and that the role of the researcher is to discover them and produce generalisable laws based on the findings. Cohen et al. (2011) further describe this ontological stance as 'naïve

realism'. Objects are independent of the knower and there is an independent discernible reality. There is also an assumption that reality is not mediated by our senses (Cohen et al., 2011), something which is qualified in post-positivism. According to a positivist perspective, facts should be observable, and this also includes that which is observable through instrumentation (Alvesson & Gergen, 2009). Knowledge is considered to be absolute and value free. I recognised that as a secondary science teacher most of my work had sat within this framework. Positivism has, as a central tenet, the idea of controlled experimentation with a view to validating theories. This leads typically to methodologies that include the abstraction of reality through mathematical modelling and quantitative analysis (Cohen et al., 2011). This is a perspective that is very familiar, and indeed comfortable to me. As a science teacher educator, part of the work I do with beginning teachers in subject pedagogy sessions involves sharing ideas about the teaching of the scientific method. The realist stance taken in this perspective is that the world exists and is knowable as it really is (Cohen et al., 2011).

Post-positivism as a theoretical perspective begins to address uncertainties in these claims. Hanson and Toulmin (cited in Alvesson & Gergen, 2009) describe the approach of post-positivism as a search for patterns: *'lying behind and explaining the manifestations of observed reality'* (p. 18). I began to see that for someone who had also engaged in the 'practice' of science, by which I mean working in a purely scientific field rather than that of science education, there was a less clear perspective. Bourdieu (2004) argues that the practice of scientists is subject to social mechanisms. Scientific life is a social life with its own *'rules, constraints, strategies and ruses'* (p. 3). From this perspective the claim for objectivity becomes more of a problem. Bourdieu illustrates this by exploring how factors such as a submission to

economic interests could undermine confidence in science as independent. This, to me, highlights the possibility of separating out perspectives on physical science phenomena: the data that are obtained by controlled experiments and repetition can be considered and the way that knowledge of those phenomena might be 'constructed' in scientific communities can also be considered.

A further blurring of boundaries occurred when I considered the practice of biology itself. One of the features of the subject is that aspects of working with organisms or organic materials means that experimental work in biology can show uncertainties and ambiguities. It is even argued that this characteristic may have a role to play in discussions about objectivity and absolute truth in science with pupils in secondary school (Reiss & Tunnicliffe, 2001). There are aspects of the discipline of biology that I feel have many similarities to social science. Fieldwork which involves the study of interactions between organisms may be conducted in a very positivist way with the researcher claiming cause and effect for observed data, but it is also possible that attempts to identify underlying patterns and possible explanations will be acknowledged to be limited and context-laden, a more post-positivist viewpoint (Blair & Deacon, 2015). Indeed, for me, one of the challenges of teaching my subject at both secondary and undergraduate level has been to reassure students writing ‘conclusions’ to small scale ecology investigations that it is acceptable to speculate on why organisms are distributed in a particular way based on evidence that is complex, deals with multiple variables and may be highly contextualised by the time of year.

The second overarching philosophy identified by Alvesson and Gergen (2009) is that of social constructionism. In this philosophy it is assumed that reality is socially constructed, and that the emphasis of research is to disclose how this happens.

Alvesson and Gergen (2009) note that social constructionism involves a *'broad, multifaceted perspective'* or set of perspectives (p. 23) and it is seen as an alternative to positivism and post-positivism. Critiques of social constructionism centre on the perception of reality as amorphous, and that research can only reveal arbitrary patterns provided by the researchers (Alvesson & Gergen, 2009). A more positive perspective would be that from a social constructionist perspective *all* research is socially constructed, even if a positivist approach is used to collect data, the difference being that social constructionism recognises this. My dilemma is that my disciplines cut across both these philosophical stances. As someone involved in education and even as a scientist, I am comfortable with the idea of social constructs, however as a scientist I would want to consider the possibility of an underlying mechanism, a 'reality' that may be giving rise to behaviours.

A moment of clarity, in terms of this study, occurred when I began to read the work of Clandinin and Connelly, (1986, 2000) see Chapter 2. They argue that individuals construct their reality in specific situations by storying it, and this was exactly what I had been doing as I reflected on my own experience. Their work was about teachers' perceptions of their role and their identity, and identity was seen as something that evolved and changed and required both the telling of a narrative and also an understanding of that narrative by others. This felt like something that I had experienced in my education roles but had taken for granted and not really stopped to consider that this was a way of *knowing* something, even though my previous experiences have been with science activities where there *are* results to be collected and discovered. The scientist part of me has also always understood that there are issues such as the limitations of instrumentation, the existence of artefacts that are a product of the observation procedure (Rasmussen, 1993), issues that call into

question the external reality of data obtained even in scientific inquiries. The other moment of clarity was that there is perhaps no need for one individual to have an overarching position on ontology and epistemology, a position that is appropriate for all types of data and knowledge. A position on ontology can be situational and it is possible to shift positions depending on the context. I am familiar with a positivist approach in my work as a scientist but equally feel able to argue for an interpretative ontology in social science research. Hunsburger (2008) makes the point that '*if there are multiple ways of knowing, there must be multiple forms of knowledge and manifold ways to represent it'* (p. 74). For this study therefore I adopted a constructionist paradigm and took an epistemological position that recognised that realities about teacher knowledge, values and beliefs were co-constructed and contextual. However, given my scientific background, I needed to be what Clough (2002) terms a 'self-conscious researcher' with particular regard to the language that I used in both my analysis and discussion to avoid unthinking usage of positivist terms around the data and the claims being made about the data.

3.3 Narratives as data

In this section I use relevant literature to discuss my justification for using narrative as a data source. Firstly, I examine some definitions of 'narrative' and then explore the use of narrative including its use in educational research. Finally, I examine the potential for knowledge generation through the use of narrative as data and include some thoughts on the definitions of reliability and validity in this context.

According to Bruner (1986) narrative thinking allows for the storied meaning that people make of these relationships. He states that narrative can be thought of as the means by which we give meaning to experiences. As such this seemed to offer

much to my study which sought to explore connections between biology teachers' experiences, beliefs, and classroom decisions. He argues that narrative knowledge is created and co-constructed through the stories that people tell about their experiences. He sees narrative, storied experience, as the most appropriate means by which people make sense of the complexities of their lives. More contemporary definitions of 'story' and 'narrative' clearly build on these ideas. Bruner contrasts this with logico-scientific thinking, which attempts to explain relationships between observed variables.

Polkinghorne (1995), in his extensive work on the use of narrative as a key tool when researching people and organisations, suggests that stories are about human attempts to clarify and 'solve' situations. His definition of narrative includes the idea of plot, a structuring that allows people to describe and understand how events and choices in their lives can be related. Similarly, Chase (2005) defines narrative as retrospective meaning making. She suggests that it can take several forms but includes in her descriptions ' *… a short, topical story or an extended account of a significant aspect of life'* (Chase, 2005, p. 651) suggesting that story and narrative are the same thing. In her exploration of qualitative research methods Elliot (2005) offers a similar definition of narrative to Polkinghorne, she defines narrative as a *'discourse with a clear sequential order that connects events in a meaningful way for a definite audience and thus offers insight about the world and / or people's experiences of it'* (Elliot, 2005, p. 3). She then takes the definition further by encompassing aspects of the characteristics of narrative from other researchers and suggests that narratives have three key features; they are chronological, meaningful and inherently social in that they are presented to a specific audience.

Ospina and Dodge (2005) make an argument for the use of narrative data in public administration research. In a similar way to Elliot, they claim that narrative can be characterised as a way of ‘re-presenting’ events in space and time and suggest five defining characteristics of their own. The essential properties of narratives are: that they are an account of selective events over time, that the narrative offers retrospective interpretations of events from a particular perspective, that the focus in the telling is on human intention and interaction and finally two linked ideas, that the narrative forms part of identity construction, the story and the telling is about the relationship of self to others, and that the narrative meaning is co-authored by both the narrator and the audience. Casey et al. (2016) also see narrative as a human sense-making process that is essential for configuring human experience. It allows disordered experiences to be structured so that the story has a plot and that an action can be viewed as consequential for the next, something emphasised by a number of researchers including Clandinin and Connelly (1986). They also argue that narrative is a tool for constructing meaning, that the storytelling is both a performance and an interpretation, with the meaning being socially constructed between storyteller and audience.

From this brief review there is a close agreement about what is meant by narrative, a term used interchangeably with the term story by most researchers, and about the common characteristics of narrative: narratives are used as a means of making sense of experience, constructing order and connections, and considering how events unfold across time. Having arrived at a definition of narrative, I now consider the use of narrative data in research.

During the past three decades there has been an increasing interest in the use of narratives as data, giving rise to what is referred to by a number of researchers as a

'narrative turn' in the social sciences (Sikes & Gale, 2006, Muchmore, 2001, Philpott, 2014). This narrative turn resulted in the increasing use of the term 'narrative inquiry' to describe systematic approaches to the gathering and analysis of the stories people tell. However narrative inquiry has been used as an overarching term for a number of methods used to capture personal and human dimensions over time rather than a specific well-defined method (Clandinin & Connelly, 2000). This broad label includes a range of methodologies such as collection and analysis of autobiographies, the use of personal narratives, life stories and life histories and narrative interviews (Clandinin & Connelly, 2000, Conle, 2000, Sikes & Gale, 2006). The increasing interest in the use of stories as data is evident in research into aspects of teacher practice and research in the area of teacher education. Clandinin and Connelly, for example, explore how teachers lead storied lives (Clandinin & Connelly, 1986, Connelly & Clandinin, 1999) and life history approaches have been used to study teacher thinking (Muchmore, 2001). Kim (2008) argues that this interest in narrative inquiry in education research reflects a growing movement away from a positivist approach to research and challenges notions of knowledge as objective and approachable only through a single means of knowing. She notes the value of narrative inquiry work as a means by which researchers can develop their understanding of education through the lived experiences of teachers and the value of such work in exploring teachers' beliefs and values. Similarly, Philpott (2014) notes the importance of narrative data as a way of understanding the development of teacher knowledge. By using stories or personal narratives as data there is a move away from approaches that attempt to explain and predict and a move towards interpretation, an attempt to understand human intent and action (Ospina & Dodge,

2005). A move to *'no longer see the world from outside - but mediating the meaning from within the world'* (p. 146).

As I discussed in Chapter 2, the focus of my study was how factors influence teachers' pedagogical thinking which I have closely linked to the concept of teachers' personal practical knowledge. Connelly and Clandinin' s work has been a key influence on this study. Connelly and Clandinin were among the first researchers to use the term narrative inquiry in an educational field (Clandinin, 2006) and importantly for this study they introduced the concept of teacher personal practical knowledge and outlined narrative methods as the way to investigate this aspect of teacher knowledge. Their conceptualisation arose from John Dewey's work theorising on experience and education. Dewey (1938) argued that all learning was based on experiences and a restructuring of experiences which could then inform future actions. Clandinin and Connelly (1986) used Dewey's ideas to develop a methodological approach that applied theoretical ideas about the nature of human experience to lived experiences in educational contexts.

A number of studies have used narrative data to examine teachers' beliefs and moral dispositions (Muchmore, 2001, Smith, 2005, Frost, 2010, Johnson, 2010, Halai, 2011, Pritzker, 2012). In these studies, it appeared that the narratives gave both researcher and participant an insight into internal drivers or psychological dimensions that might be shaping aspects of their practice as teachers. These studies offer some common insights:

1. Researchers can gain an understanding of relationships between life stories and teachers' construction of beliefs.

2. Teachers can use stories to develop an understanding of how they are constructing their identity.

3. They share an implicit understanding that other practitioners might be able to clarify their own beliefs through the narratives that they read.

Caduri (2013) also explores the epistemological foundations of narrative research, specifically in education, and emphasises that narrative research is aimed at understanding teachers' actions, rather than looking for mechanistic relationships in behaviour, arguing that the link between past experiences and present teaching practices is not causal but teleological. Earlier Brockmeier (2000) highlighted the *'retrospective teleology of autobiographical narrative'* (p. 60) as a key characteristic of this type of research. He noted that in the telling of an autobiography the life story begins at the point of inquiry and the participant reconstructs the past as if it were purposefully directed towards this point. This is relevant to my study as it suggests that my participants would be making sense of their past experiences by considering how they perceived them to be influencing their current beliefs.

The use of narratives as data, however, is not without its challenges Kvale (1996) examines ideas of reliability and validity in qualitative research methods in general, some of which are relevant to the design of this study. In positivist research reliability refers to the replicability or stability of research findings and validity is defined as the ability of the research to measure the concepts of interest. Kvale refines the term validity and suggests two categories. The first, 'internal validity' refers to the idea that any data generated is *not* an artifact of the research design, for example in the context of this study that might include leading or restrictive questions in an interview. The second category is 'external validity' and is a measure of how far the

findings of the research can be applied to a broader context. However, Kvale notes that the root of these terms originates with the positivist paradigm and may not always be appropriate as a model for evaluating qualitative research. He does, however, argue that even if our focus is on narrative data, we should be asking whether the accounts are accurate or valid representations of reality. Developing similar ideas, Polkinghorne (2007) considers the term validity to refer to the believability of a knowledge claim and argues that this should be based on the evidence and the arguments made in support of the knowledge claim. In his view validity rests on a consensus within a community and he draws on the ideas of Habermas to argue that only sound arguments should influence this judgement. He further suggests that validity judgments should be based in the everyday practices of the individuals within the community being researched, and not in some objective view from outside that community. Polkinghorne goes on to argue that claims to understanding of human experience should include *'personally reflective descriptions in ordinary language'* (p. 475) and that validating knowledge claims is an argumentative practice. Through this approach readers of knowledge claims can consider their confidence in the claim, not by using statistical calculations of confidence limits, but by making judgements about how much the evidence and arguments convince them.

Bassey (2001) who initially came from a physical science background, argued that the study of single events in education may be more useful to teachers than attempts to search for generalisations simply because of the complex, multi-variable nature of teaching interactions. He also discussed the value of relatability - the degree to which a teacher reading the study or report could relate what is presented to their own context which links directly to Polkinghorne's argument for '*reflective*

descriptions in ordinary language.' He suggests formulating the outcome of empirical research in education as a 'fuzzy generalisation' expressed as *'particular events may lead to particular consequences'* (Bassey, 2001 p. 6). He asserts that the generalisability depends on the fit between the context of the study and the context to which one might apply the concepts and conclusions.

In a similar way Muchmore (2001) summarises his work by noting that the knowledge gained through narrative research has '*little value for making generalizations about other teachers in a statistical sense*' (p. 105) but argues that such knowledge may be a useful tool for developing one's own beliefs and practices. He draws on the work of Donmoyer (1990, cited in Muchmore) to widen the definition of generalisability so that it includes the learning that occurs when teachers read research texts based on individual, context laden cases. This is not generalisability in the positivist sense but rather an ability to reflect on how the narrative applies to one's own situation. This idea of the usefulness of narrative inquiry insights is echoed by several key researchers in the field. From Bold (2012): *'one key aim … is to foster readers' reflection on their own or others' practice and to encourage comparison with their own stories'* (p. 301) Similarly Conle (2000) uses the concept of 'resonance' in her descriptions of narrative inquiry with pre-service teachers, explaining that when reading narratives, the beginning teachers react to the stories with narratives of their own. Perspectives on validity in this study are shaped by the work of Conle and Muchmore who argued that insights from research are valid if they engender recognition and reflection when read by individuals who then consider their own stories.

Polkinghorne (2007) summarises what he terms the 'validity threats' when using narrative data as the potential mismatch between an individual's actual experience

and their storied description. He states that this could be due to a number of factors such as the limits of language to describe the experience, the limits of the reflective process, a resistance by the storyteller to reveal social complexities and complexities arising because the meaning of the story is co-created between researcher and participant. He further cautions that making meaning in this way requires time. These arguments about how to define the validity of interpretations of data such as narratives fit with Charmaz's approach to grounded theory methodology (Charmaz, 2000) which I discuss in the next section.

3.4 Grounded Theory Methods

In this section I give an overview of the origins and development of grounded theory methodology and justify the use of this approach in this study.

Grounded theory (GT) originated in the 1960s with Glaser and Strauss (1967). It offered a systematic qualitative procedure that could be used to generate a broad theory or explanation of processes and was initially conceived as a challenge to criticisms that qualitative research was unscientific and lacking in rigour (Creswell, 2012). GT differs from many other research approaches in that it does not test a hypothesis but aims to discover the theory implicit in any data collected (Glaser, 1992). GT was an appropriate choice given that I wanted to find out what my data were telling me about biology teachers' experiences with their subject and their perceptions of how their classroom decisions were being influenced. I was also aware of the benefit of a systematic approach to data analysis and an existing framework for the interpretation of data for a beginning researcher. I was, however, aware of the lure of such a systematic approach given my positivist background. Mindful of the ontological journey that I had been on throughout the study I agreed

with Singh and Estefan (2018) about the importance of selecting the appropriate approach to GT. They offer a simplified overview that suggests there are three main approaches to GT; that of Glaser and Strauss (1967), that of Strauss and Corbin (1994), and latterly that of Charmaz (2014), although Charmaz herself argues that it is more accurate to consider it as a 'family' of methods with a degree of contention around the details (Charmaz, 2003). She concedes that it can be considered that there are three dominant designs.

I will consider the three approaches as outlined by Singh and Estefan (2018) before justifying my choice for this study. All three approaches include similar procedures and similar vocabulary. They all involve generating data directly from participants in natural settings. Data analysis and data generation are done throughout the process and early data analysis informs the generation of further data. The aim is to develop an understanding of a participant's experiences and interpret how they are making sense of their own perceptions and actions (Charmaz, 2014). Where the GT approaches differ is in terms of ontology and epistemology and the choice of approach needed to align with the perspective that I discussed earlier in this chapter.

Glaser and Strauss' initial GT approach (Glaser & Strauss, 1967) and Strauss and Corbin's reinterpretation of this (1994) both take a more positivist and objectivist approach to the research (Charmaz, 2014). Glaser suggests that there is a reality to be discovered in the data and that the data will *'speak for itself'*. The researcher is conceived as neutral and other (Singh & Estefan, 2018). Strauss and Corbin's perspective, developed in the 1990s, modifies this and argues that it may not be possible to see reality as it really is, although continues to suggest that there may actually be an objective reality. The researcher's personal beliefs and values are

acknowledged but there is an attempt to control this personal influence in order to maximise objectivity.

As familiar and potentially comforting as it might have been to adopt this vocabulary of 'controlling potential variables,' it was important to remember that the idea for this study arose out of *my* story about being a biology teacher and my personal examination of my own values and beliefs around biology teaching. This brought me to the GT approach developed by Charmaz. In contrast to the first two designs the approach outlined by Charmaz is aligned with my constructionist ontology. Charmaz adopts what she terms a 'constructivist' approach, assuming that both the data and the analysis are created from the shared experiences of the researcher and participant which can also add a form of 'participant validity' (Charmaz, 2000). This approach examines the meanings constructed by participants *'from as close to the inside of the experience as they can get'* (Charmaz, 2000, p. 313). In contrast to Glaser and Strauss and Strauss and Corbin, Charmaz argues that there are multiple perspectives on reality and that the researcher engages in interpretation using personal and professional insights. In Charmaz's approach the researcher uses intuition and imagination from their personal experiences to interact with the data and relevant literature to construct an explanation for patterns and processes. Charmaz uses the same systematic approach for analysis as 'classic' GT including initial or open coding of data which can be grouped into concepts, theoretical sampling, that is, looking for data that are relevant to any emerging categories, and constant comparison to look for the most significant codes. Where her approach differs is that it allows a flexibility of approach, and the researcher has an acknowledged role in the focus of codes and themes; their personal position is part of this and the move towards a focus is more spontaneous. Where Glaser outlines

an inductive approach, with the neutral researcher discovering patterns in the data, Strauss and Corbin include a deductive approach, the testing of abstract ideas against emerging data. In her approach Charmaz also allows for abductive reasoning, suggesting that data will be incomplete but may yield plausible conclusions, that although not generalisable, can inform practical decision making. Given the limited scope of this study and the aim to inform professional practice this is also a key consideration in my choice.

Using literature

In traditional GT there is no requirement to review literature (Glaser, 1992) as this may influence the researcher's analysis. The GT approaches developed by Strauss and Corbin and Charmaz in particular suggest using literature as the researcher considers appropriate in the initial stages of analysis, suggesting that the literature can be used as another set of data, another voice that contributes to the researcher's insights. In this study it became apparent at an early stage of open coding, before the final interviews took place, that it would be useful to look at literature around teacher knowledge, and this is the literature which informs Chapter 2. Following from this, as I wrote memos, I identified possible literature that would help me to explore emerging ideas (see Appendix 4, p. 241 and Appendix 7, p. 267).

3.5 Justifying a combined approach

There is a precedent in the literature for the use of qualitative methodologies that combine elements from narrative inquiry and grounded theory approaches (Earthey & Cronin, 2008, Floersch et al., 2010, Lal et al., 2012), with researchers suggesting that a pragmatic rationale is often given for this combined approach. In considering the design of my study I knew that I wanted to elicit teachers' stories about their

experiences of teaching biology and that I wanted to allow the participants to share their wider stories rather than simply answering questions that I posed. I wanted to share in their interpretations and meaning making. However, I also wanted to consider how their experiences might be influencing their actions and interactions in the classroom and this would involve an interpretive analysis that fitted with Charmaz's approach to grounded theory. I was also aware of a personal need for a clear framework for my analysis as a beginning qualitative researcher. I wanted to carry out an analysis of the interview data that allowed me to identify possible themes within the narratives and consider how these might relate *across* participants and also to my research questions. I was aware that I did not have an existing theoretical framework to suggest themes and categories at the start of my study, instead my aim was to develop arguments grounded in the data. Another important consideration was what I was planning to consider as the 'unit' of my analysis (Lal et al., 2012). Because I wanted to identify themes in the teachers' stories and compare these across participants, I would not be using whole stories as the unit of analysis but intended to code sections of the narrative and identify emerging areas of interest, in effect fragmenting the narratives. I also decided that within the limited scope of this study I would focus on the content of the teachers' narratives rather than their use of language or the manner in which they delivered their stories. These requirements strongly suggested that my analysis would need to be based on a grounded theory approach rather than narrative inquiry approach to analysis. Charmaz (2006) offered a clear framework for analysis that would allow me to examine the themes in my data across participants and enable the generation of concepts from these themes. When considering the use of a combined methodological approach, however, it is important to ensure that the methods are

situated within an identifiable and compatible epistemological perspective (Lal et al., 2012). I believe that my use of Charmaz's constructivist approach to grounded theory for my analysis and conceptualisation and the use of narrative inquiry methods for data collection satisfied this requirement. Combining the two approaches did present a dilemma in terms of the presentation of the data. There were tensions between my aim to tell biology teachers' stories about their experiences and the need to fragment those stories to explore and present themes. I consider this in more detail in section 4.2 (p. 88)

3.6 The design of this study

This study involved generating narrative data through three semi-structured interviews with each of five participants. The interviews took place over the span of two academic years due to the workload constraints of participants. All five participants were practising biology teachers at the time of the study.

3.6.1 Selection of participants

Participants were selected through purposive sampling (Elliott, 2005). Based on insights from the interviews with a colleague that I carried out as part of my pilot study, I felt that it would be beneficial to select from teachers who had already engaged with projects or research in partnership with the university as they would already have a degree of trust and an openness to becoming involved. However, I was also aware that this might also mean that I had selected participants who were already considering their pedagogical thinking, and so may not have been typical of many biology teachers. I also wanted to avoid selecting participants from my current PGCE cohort of pre-service teachers, partly due to ethical issues around my relationship with them as Course Leader and assessor, partly because I was

interested in how subject beliefs continue to develop in the school setting and also because, if possible, I wanted participants to have a range of experience.

To avoid potential power relationship issues I was keen to avoid working with teachers from schools that I visited regularly in my Initial Teacher Education (ITE) capacity because of the potential for conflicts of interest if they were involved in the assessment of my ITE students, and used contacts made by the Centre for Science Education, as it existed at the time, for my initial request letter. These contacts were made with schools in the South and West Yorkshire and North Derbyshire regions through the centre's Continuing Professional Development (CPD) provision. My thinking was that using these contacts for my initial approach would allow me to contact staff who already had a history of involvement with subject CPD and were aware of the research role of the Centre for Science Education or the Science Learning Centre and were not directly involved with me in an ITE capacity at the time of the study. The final consideration was to avoid working with participants where there might be constraints on the pedagogical approaches that they could adopt, I wanted participants to have as much control over their classroom decisions as might be possible in order to get an understanding of the range of factors influencing these decisions, because of this I avoided approaching participants from school contexts that expected a very controlled and consistent approach from each teacher by providing pre-planned and required pedagogical approaches specified for each lesson. Having identified ten potential participants, I then sent an initial information letter with an addressed, pre-paid envelope. Five participants responded and were sent a written letter inviting them to a face-to-face briefing and question and answer session. At these meetings consent forms and pre-paid envelopes were given out. This approach to obtaining consent using a pre-paid envelope allowed for thinking

time and was designed to reduce the potential for participants to feel pressurised to consent during a face-to-face meeting. All five participants consented to then join the study. (See Appendix 1, p. 237 for a copy of the consent form.) Initially participants were allocated letters to ensure anonymity but as I wrote the study, I felt it more appropriate to allocate pseudonyms given my background and my ontological shift I wanted to ensure that I kept thinking of my participants as people rather than lapse into considering them as sources of data. A summary of their experiences and an overview of their respective school contexts can be found below in Table 3.1 and Table 3.2:

Table 3.1: Background information about participants

Participant pseudonym:	**Number of years teaching at the start of data collection:**	**Teaching qualification / route:**	**School context:**
Arron	12	PGCE Chemistry	Worked in several schools
Becky	2	BSc Science with Education and QTS	Worked in one school left to teach in Vietnam at the end of the data collection
Chris	NQT	PGCE Biology	Changed schools part way through the data collection
Dan	3	PGCE Biology	Only worked in one school
Emily	4	PGCE Biology	Only worked in one school

Table 3.2: Information about school context

School / participant	**Provision:**	**Status:**	Free School Meals:	EAL pupils:
Arron	11-18 co-educational Approximately 1600 on role	Catholic Voluntary Academy	24.5%	2.1%
Becky and Chris	11-16 co-educational Approximately 1000 on role	Single Academy Trust	22.4%	6%
Chris	11-18 co-educational Approximately 1500	Academy	8.8%	0.1%

	on role			
Dan and Emily	11-16 (since 2016) co-educational Approximately 600 on role	Academy and from 2019 part of a MAT	34.4%	0.6%

The school context information is given here as it informs an element of my discussion in later chapters. (Information from https://www.get-information-schools.service.gov.uk/Establishments/Establishment/Details)

3.6.2 A note on the number of participants

Even qualitative studies identified as having a large number of participants (Johnson, 2010, McIntyre, 2010, Wenger et al., 2012) use a relatively small sample size compared to more positivist research studies: indeed, the largest of those reviewed involved 20 participants. Goodson and Sikes (2001) note that research samples in research that uses narrative data, particularly those using life history, are usually quite small. The authors are clear that the epistemological positioning of such studies values the subjective. They refer to the data as emic and idiographic, centred on the meaning that people make of their situations and concerned with unique events, and because of this, they argue, a large sample is inappropriate. Life history deals with participants rather than subjects. The aim is to construct rich data through interaction between the participant and the researcher rather than to ‘collect’ information from an implied experimental sample. They give some guidance on an appropriate number of participants which is related to the aim of the proposed research. If the aim is to reveal shared patterns of experience or interpretation within a group, then the sample size is considered adequate when there is enough data to do this. My aim was to look at some of the experiences with biology that could be shaping teachers' approach to the teaching of biology and for this reason I wanted to collect data on more than a single case study. Equally, I was not trying to develop generalisable concepts, nor was I trying to link particular school contexts with

emerging themes and did not expect to reach a point of 'empirical saturation' with my data in this study (Adler & Adler, 2012) but recognised that it would be more of an initial exploration into biology teachers' developing subject identity. I also had to consider the time that I had available to conduct the study alongside my role as PGCE course leader. I therefore felt it appropriate to limit my sample size. Within the scope of my study, I felt that multiple interviews with five participants with varying years of experience working in different school contexts would generate rich data to analyse.

3.6.3 Positioning myself

An explicit consideration of my position in this qualitative study was important. In all qualitative research the researcher plays an important role in both the data collection and analysis. Strauss and Corbin (1990) use the term ‘theoretical’ sensitivity to describe the researcher's level of insight into the researched area and their ability to construct meaning through an understanding of the vocabulary used and the nuances expressed when participants are telling their stories. However, they also placed an emphasis on the need for the researcher to have an element of otherness and to enter the research with few predetermined thoughts. Charmaz (2014) reshaped this idea and noted that considerations about the role of the researcher do not just relate to objectivity or lack of objectivity but also to explicit consideration and acknowledgement of the positionality of the researcher.

In this study the focus was on the work of secondary biology teachers and their perceptions of their role. I considered myself to have theoretical sensitivity in that I shared experience of the role with my participants, having been a secondary biology teacher for over 20 years myself. I also have shared experience of biology teaching

in the region in my current role in Teacher Education and have worked with some of the participants in the past as pre-service teachers, something I discuss in the ethics section. I am not, however, situated within any of the participants' contexts so although this gives me a common understanding and vocabulary when working with participants it should reduce the tensions and power imbalance that would arise if working with participants directly within my institution or currently training (Blythe et al., 2013) which fits with my approach to GT. However, it is still an issue that the perception of a researcher from a university visiting teachers in schools could be viewed as an imbalanced relationship (Bevins & Price, 2014). According to Nakata (2015) my position fits the profile of inbetweener research. The study demonstrates aspects of insider research because I am working with participants in a broad context that I am very familiar with and some of the participants have past associations with me as pre-service teachers. However, I was collecting data outside my own institution in specific school contexts that I had no connection with, so the study also demonstrates elements of outsider research.

Dwyer and Buckle (2009) discuss the researcher ‘in the space between’ as a challenge to the insider/outsider dichotomy and argue that a qualitative researcher's position is always complex and that even as a complete insider, for example someone researching biology teaching within their own school setting there would be tensions in the role. They argue that most researchers do not fully occupy ether position. My position is one of familiarity of the area being researched. I have some of the benefits of being a member, a shared experience and in some cases a working relationship with the participants, which seemed to foster trust and openness. Dwyer and Buckle (2009) refer to the 'legitimacy that some degree of 'membership' can give the researcher. However, this is not without its problems.

There is the potential for participants to give abbreviated answers under the assumption that the researcher knows what they mean, for the participants to be unduly influenced by what they feel that the researcher may want to hear and the ever present possibility that analysis and judgements are informed by personal experience (Dwyer & Buckle, 2009) However, Charmaz (2014) argues that the professional insight of the researcher can be of considerable benefit in her approach to GT providing there is an awareness of one's personal bias. I decided to address this by including aspects of my own story as additional data sources and to explicitly consider how these might be affecting my beliefs and trying to include aspects of my biology autobiography in any comparisons and cross checking (although only two stories are included in the body of this study other examples can be found in appendix 5b (p. 261). An example of this occurred when talking to Chris about his work with an outside expert. I was aware that this experience resonated with my own experiences as an early career teacher and the impact that this had on my professional development and needed to ask Chris about these experiences again in the third round of interviewing to ensure that I was not over emphasising the significance of the interview data.

Reflexivity, the need for the researcher to reflect on data collection and interpretation, is an important aspect of qualitative research (Denzin & Lincoln, 2011) and it was important that I remained aware of my own positionality on the processes and outcomes in this study.

3.6.4 Data generation

In this final section I draw on the work on active interviewing by Holstein and Gubrium (1995) and episodic interviewing by Flick (1997) as both sources informed

my approach to generating narrative data. Like other qualitative researchers, they caution that it is important not to think of the interview conversation as a 'pipeline' for the transmission of information and argues that the interviewer is neither a neutral conduit nor a source of distortion in the data. The interviewer is an integral part of the knowledge construction as both participant and interviewer are actively involved in the making of meaning. In order to facilitate co-construction Holstein and Gubrium suggest a creative approach to interviewing that will allow for the establishment of trust and a climate for mutual disclosure, so unlike interviews with a more positivist stance, Holstein suggests that the interviewer can, and should, show an interest in the participant's feelings as they tell their story. Citing Pool, Holstein and Gubrium (1995) note '*every interview … is an interpersonal drama with a developing plot*' (p. 14). They suggest that it is important to put aside notions of a neutral interview with standardised questions that are read from a script but to instead consider the interviewer's role in activating narrative production. Holstein and Gubrium outline an approach that, far from being dispassionate and neutral, offers ways of making connections and conceptualising in the developing narrative. They argue that this should not be considered contamination of data but is about facilitating the storytelling. An example of this can be seen in the excerpt from the first interview with Arron where we are both considering the impact of technology on our classroom practice:

> *P: I often talk to the students about I remember teaching before the internet... and now just the sheer high quality of animations and simulations that you've got out there now in particularly in the microbiology I just think how on Earth did I manage before? Really, it was just*
>
> *A: Pens, pipe cleaners*

P: bits of string and like you said, pipe cleaners, it was just mad

A: Yeah. I mean I went to school before the internet so I …

(Arron, Interview 1)

In this example, I find myself sharing my own experiences of how biology pedagogy has been changed by technology. This is a moment of mutual recognition of some of the challenges that biology teacher faced when modelling abstract concepts. It also illustrates a moment of connection between interviewer and participant and generates further detail on how Arron feels that technology is impacting on his work in the classroom.

Another influence on my method choices came from Flick (1997) who outlined an interview technique that she terms episodic interviewing. Episodic interviewing is a technique that allows the interview to remain open enough to allow the participant to select episodes to recount. The interview is based on a guide to ensure that key themes are discussed but remains open. Flick advocates having a clear structure to the questions, with phrases that lead the participant through the narrative, but attempting to balance an approach that will allow the participant to structure the narrative while still allowing the researcher to ask deepening questions that follow thematic directions. Charmaz (2014) refers to a similar process of 'intensive interviewing' which is used in GT, in which the interview is directed and shaped, giving a focus to the topic of the interview but also '*providing the interactive space and time for the participant's views and insights to emerge'* (p. 85)

3.6.5 Pilot study

In order to trial a style of open interviewing that would encourage participants to tell their stories I conducted a pilot involving a colleague from the university, also a former biology teacher, who I knew would give me constructive criticism and

feedback on the approach. From my pilot study it was clear that the pilot participant found it easier to think about the story that they would tell when given an initial stimulus and time to reflect. This was a chance discovery. As the pilot participant was a colleague, we spent some time organising a suitable interview time and completing consent forms and discussing the proposed content of the interview, both discovering that as young children we had read the Enid Blyton book 'The Children of Cherry Tree Farm', essentially a simple natural history book in the guise of a children's adventure story. My colleague then reread the book before the interview and noted that this action reminded her about aspects of her journey to biology teaching.

In the light of this experience, I decided to encourage some initial stimulus for participants before their initial interviews. One possibility was to ask participants to revisit something from their past that had influenced their choices. However, I felt that there were both ethical and logistical issues involved in asking each busy participant to spend time identifying and reading a similar personal stimulus for reflection. I therefore considered other ways of generating this stimulus. Henze et al. (2009), for example, used a method that they term ‘The Storyline Method’ having encountered difficulties with eliciting answers to questions around work-related learning with teachers. The ‘Storyline,’ a visual representation of the teachers’ perceptions of their confidence levels in teaching a new syllabus as a graph was used as a ‘trigger’ before the teachers were asked to tell their stories (Beijaard et al., 1999). In a similar way Alsup (2006) in her research on identity growth in pre-service secondary school teachers advocated the use of photographs as visual metaphors to stimulate and enhance her participant’s personal narratives. Alsup (2006) argues that the expression of metaphor is essential to the identity development of research

participants and used the photographs alongside both personal narratives and auto-ethnographies.

With these examples in mind, I decided to use a visual elicitation method in the first phase of my study before the initial interviews. Participants were asked to take photographs of objects, collections of objects, images, or texts that they felt represented their core beliefs about biology teaching in some way. These representations (see example Chapter 4 section 4.2, p. 90 and Appendix 2, p. 239) then formed the basis of a semi-structured interview in which I asked them to tell the story behind the images. I chose this method as it was technically very easy to comply with: all the participants had smart phones with cameras, and it seemed to be something that could be done quickly as ideas came to them in their school context. It also offered the possibility that participants would use images that were metaphors for their beliefs (Alsup 2006) as well as direct representations. The exercise produced examples of both types of images (see examples in Chapter 4). As with other researchers cited earlier Alsup was of the belief that teachers constantly translate their philosophies and beliefs into action in their classrooms.

Although I was interested in the possible influence of previous experiences with biology on classroom decisions, I chose not to include classroom observations as part of this study. I felt that the ethnographic methodology implicit in such an approach, the observation of the teacher 'as other', would be a mismatch with my epistemological position and I agreed with the position of Goodson (1994) that in order to understand teaching it is important to understand the person who teaches. I felt that classroom observations would not contribute to this aim. I also felt that there were ethical issues around power relationships and the potentially judgemental

position of the researcher that would create tension around the mutual trust required for life story interviews (see Section 3.6.9)

3.6.6 The number of interviews

There is very little agreement in the GT literature about the number of interviews to conduct however the guidance that Charmaz (2014) gives is to consider the nature of the study. She suggests that 12 interviews across a study would be an appropriate number if the themes being explored were concerning experiences among a relatively homogenous group. As my participants and I were all secondary school biology teachers who share a language and an understanding of the contexts and the experiences that we were discussing, I felt that the discussions did not include what Charmaz refers to as 'secrets, silences and boundary spaces.' I therefore felt that a sequence of three interviews per participant, giving a total of 15 interviews plus my personal autobiographical notes, would generate a rich but manageable amount of data for this study given that both I and the participants had demanding, full time roles.

When looking at the third set of interviews in detail this appears to be validated. The interviews tended to either be shorter or revisited themes that had been discussed previously or became more wide-ranging and general as we discussed future ideas.

3.6.7 The interview process

Phase 1:

The initial step was a face-to-face meeting and a briefing about the study at the university. This initial briefing dealt with consent, an overview of the study and covered the first set of 'instructions.' Participants were also informed that they could withdraw once they had left and thought about what was being asked. None of the

participants decided to withdraw at this stage. The participants were asked to use smartphones or digital cameras to take photographs that they felt represented how they felt about biology teaching and then email these to me. The prints of these images then provided stimulus material for the first set of interviews. The purpose of the photographs was to help elicit the participants' stories.

During the first set of interviews, each participant was then asked to tell the story behind the images they had produced. The interviews were recorded and then transcribed. As transcription formed the first stage in my analysis this was carried out by me rather than a professional transcription service. (See Appendix 2 for an example of the images and part of a transcribed interview 1, p. 239, and Section 3.6.8 for discussion of transcription as the first phase of analysis). The initial transcription allowed me to identify emerging themes and suggest specific questions for the next interviews. I discuss my approach to transcription in further detail in section 3.5.8 of this chapter.

Questions were kept very open and brief as the idea was to allow the participants to talk and tell stories.

- Tell me about the images?
- How do you feel that this represents what you feel is important about biology teaching?

Throughout the interviews I tried to encourage participants to tell their stories rather than simply sharing perspectives by using language to prompt this, for example actually asking them to 'tell me the story of how you became a biology teacher?' or 'Tell me about your journey to becoming a biology teacher?'

For the initial interviews most of my responses were simply prompts as the participants were telling the stories behind the images. However, I wanted the process to feel more like a conversation than an interview in order to put participants at ease. As the interviews progressed, I found that I was sometimes checking that I had understood a particular aspect of their story, for example in the excerpt below with Arron I provide a summary for 'checking':

> *P: and again, I think in the next interview we might explore that a bit more. But the other thing that struck me as we were talking about it was a sort of commitment to understanding, so again that sounds ridiculous from a teaching point of view, but a commitment to sort of, get pupils to model things and to understand things and to be a little bit creative about the way they go about making sense of them. Erm… because you showed me a couple of things that involved the modelling and, again you mentioned creativity with the cake so that, you know that really struck me*
>
> *A: yeah, I, I … I think if we're not creative it's going to get boring... there's very little practical you can do at all Biology isn't a... I don't think … a practical science. Many people disagree with me, people do but I don't think it is because as I was saying to you about the heart... I think sometimes when we do practical in biology if we're not 100% clear about what's going on*
>
> (Arron, Interview 1)

I also found that I included additional questions on points of information as the interviews progressed. In the example below I ask Becky about teaching in specialisms:

> *P: How long have you been teaching now, quite a while?*
>
> *B: Yeah, so third year*
>
> *P: erm so are you … do you divide it by specialisms here?*
>
> *B: yeah, we do. My first year I was a … I did all 3 I was teaching physics and chemistry as well but here you teach all 3 at KS 3 but obviously that's only 2 years now*
>
> (Becky, Interview 1)

These additional questions arose naturally during the interview process and were captured as I transcribed the interviews.

I then began to code the interview texts and identified emerging themes. I produced an interpretive account, complete with images to share with participants (McCormack, 2000). These interpretive accounts were used to check my interpretation of the main ideas from the interviews with the participants and they also formed the stimulus for the participants for the second interviews, allowing them to recapture the threads of the stories that they had told previously (an example can be found in Chapter 4)

Phase 2:

I then used semi-structured interviews to encourage participants to tell wider stories about their subject experiences. Using any emerging themes from the Phase 1 interpretive accounts I asked participants to tell me the story of how/why they became biology teachers: what factors did they feel had influenced the way they perceive biology teaching and were there factors that affect their preferred pedagogical decisions or any tensions arising between their values and beliefs and their current context? The questions can be found in Table 3.3 below:

These interviews were recorded and transcribed.

Table 3.3. Questions used in the second interviews showing where these were personalised if appropriate:

Question:	**Specific detail if appropriate:**
Why did you become a biology teacher? What do you think were the events or circumstances that led to you becoming a biology teacher?	**Participant A:** You briefly discussed how you became a biology teacher in the first interview - talking about an initial interest in medicine - can you tell me more about this journey? **Participant E:** You mention an initial

	interest in veterinary medicine that transformed into an interest in studying zoology at university as the start of your journey to become a biology teacher. Can you tell me more about this journey?
What were your experiences with biology before you became a teacher?	**Participant A:** You talk about a pivotal moment when you were at university (the death of Mark Vivien-Foe) that stimulated your interest in human biology in particular, can you remember any other experiences with the subject of biology before then?
Do you feel that any of the experiences that you have talked about have influenced the way you teach in any way?	
What are your most vivid memories about the process of actually learning to teach biology?	
What are your feelings about your school context and how it affects your decisions when teaching biology?	**Participant C:** I particularly noted your comparisons between the biology teaching that you do and the physics teaching that you do - could you expand on this at all?
*In these first interviews a comment was made about the 'status' of biology as a subject with other science teachers and how biology is perceived by others. Have you any thoughts on this?	
Is there anything else that you would like to share or say before we stop?	

*The sixth question arose out of the initial analysis of the transcripts from phase 1.

Phase 3:

This time I gave a summary of the key points from each of the second interviews at the beginning of the final meeting with my participants. This final phase had two purposes: firstly, an opportunity for participant validation of the ideas identified up to this point and secondly an opportunity to open out the scope of the stories in this way I was able to generate additional data to elaborate and refine any emerging theory. In a similar way to previous interviews, I took a conversational approach to the interview process and additional questions often arose naturally although in most

examples these were questions aimed at clarifying and consolidating what the participant had said, for example this excerpt from the third interview with Chris is about the organisation of a sequence of lessons in a topic:

> *C: we cram in a microscope practical to one lesson, spend two, three lessons looking at different things, drawing things, talking about it. Let's spend some real time exploring it erm … and I think that's what it is because we've got so much content to cover*
>
> *P: Hmm*
>
> *C: Erm … but we're covering it twice, teaching the same lesson*
>
> *P: I was going to say you can group it, can't you?*
>
> *C: Yeah*
>
> *P: so, in a way it's not about a list of facts, but it's about a group of underlying principles?*
>
> *C: Exactly*
>
> (Chris, Interview 3)

I deliberately chose to ask fairly generic questions in order to frame the final interview, with the first question acting as a recap in order to elicit any other thoughts on current influences on the participants' pedagogical thinking. I was also interested in responses to the second question as there had been very little mention of experiences from initial teacher education in the responses at this point. Questions included:

What do you feel is currently influencing the way you approach biology teaching?

What experiences have or would have been helpful as a beginning teacher?

Do you have any thoughts on the biology teacher you want to be in the future?

Do you have any thoughts on the impact of the introduction of Required Practical work? [Depending on the timing of the interview]

Any other thoughts that you would like to share at this point?

3.6.8 Transcription

Much of my approach to the transcription of the interviews came from Davidson (2009) who conducted a review of transcription literature from 1999 onwards. Transcription is defined as the transformation of sound to text and requires some decisions about exactly what is captured in this process. Only certain features of talk and interaction are transcribed as it is not possible to capture everything. Bucholtz (2000) considers the process of transcription to be a continuum between two extremes. At one end there is 'naturalised' transcription which is a detailed transcription of everything that is said and captures elements other than the verbal, such as pauses, laughter and 'ums and ahs' at the other extreme is 'denaturalised' transcription which focuses on the speech but omits stutters, pauses and idiosyncratic speech patterns. Oliver et al. (2005) note that it is important to remember that transcription is a representational and interpretive process and cautions against thinking of them as objective accounts of recorded data. Because of this I decided to consider transcription the first stage in my data analysis, as it allowed me to begin memoing, and to carry out my own transcription rather than a third party.

I also chose to adopt a more naturalised approach to the transcription. I noted pauses, laughter and included as faithfully as possible involuntary noises such as ums and ahs, I also retained colloquialisms such as 'yeah' and 'cos' and where speech included non-standard elements such as 'it were' instead of 'it was' these were also retained. I felt that the pauses and involuntary noises were often indications of the participant thinking, remembering or constructing a sequence of the story so I felt that these were potentially important. I also retained repetition and filler phrases that were a type of speech 'punctuation' such as 'like' and 'sort of.'

However, I did not carry out any conversational analysis (Albert, 2017) so only kept in very basic information such as pauses and laughter. I did not feel it was appropriate to make extensive field notes as the interviews were designed to feel more like a conversation, so where an aspect of the talk was particularly notable, I commented on it within the interview for the recording, for example in one interview I mention the participant's tone of voice and body language as being very positive. He was clearly excited about what he was saying, leaning forwards and smiling at his recollection of incidents.

Apart from the small number of colloquialisms mentioned above I stayed with conventional spelling and did include punctuation where I felt that it would assist when reading back. I did not attempt to phonetically represent accents. All the participants spoke clearly, and I felt that a phonetical representation would not contribute any further information. In this study I was both the interviewer and the transcriber, and my key focus was on what was said, the story, rather than how it was said. Although my approach was mainly to produce a naturalised transcript, I made decisions to standardise the written text to some extent while preserving any idiosyncratic elements of speech. I wanted to capture *what* was said but maintain a record of hesitations and repetition for the next stage of analysis. I felt that although extremely time consuming my role as transcriber allowed me to begin the process of interpretation and maintained the confidentiality of the participants as no-one else had access to the original recordings. As I transcribed the interviews ready for analysis, I allocated pseudonyms to the participants. I wanted to avoid, even subconsciously, considering the participants as ‘experimental subjects’ and felt that pseudonyms were more respectful than referring to them as letters. See the table below for pseudonyms.

Table 3.4 participant pseudonyms

Participant:	Pseudonym:
A	Arron
B	Becky
C	Chris
D	Dan
E	Emily

3.6.9 Ethical considerations

Formal ethical approval was given for this study (See Appendix 3, p. 240). However, there were several key issues to continually consider when working with my participants.

Consent forms were completed before each of the three individual interviews for each participant and participants were reminded of their right to withdraw both at the end of interviews and when setting up appointments for the next interviews.

It is possible that narrative interviews could lead participants to disclose sensitive and emotionally charged information. I therefore restricted the life story focus to the participants' trajectory to becoming a biology teacher which reduced this risk. I was also prepared to suspend interviews should it become apparent that there was a negative emotional impact on the participant. I felt that the use of semi-structured interviews rather than formal structured interviews also alleviated some of that risk as it was the participant's choice as to what they wanted to tell me about. Clear confidentiality and anonymity protocols were in place and the interviews were conducted in a place of the participant's choosing. In most cases this was a private space in the participant's school because it was more convenient for them. They were also made aware that if they felt conducting the interview at school would have been inappropriate there were alternative, neutral venues that could be used.

My method of producing an interpretive account of the interviews, initially written and then an oral summary that was captured in the recording of the final interview gave each participant the opportunity to review the initial stages of analysis and add to or remove any parts of the transcript and / or interpretive story that they felt was inaccurate or compromising. There was the possibility that comments in the narrative could highlight barriers that were intrinsic to the school context. For this reason, I avoided working with participants in science departments that I visited regularly in my ITE role and data about the school context was anonymised.

Discussions around pedagogical issues could have led to the participants feeling scrutinized, assessed, or judged. Briefing materials and pre-interview discussions therefore included a collaborative discussion around parameters and ground rules and included the usual confidentiality briefing.

The audio and transcript data were stored to conform with Sheffield Hallam University (SHU) faculty norms in accordance with the 1998 Data Protection Act. Data was anonymised at the point of transcription. Consent forms were stored securely on SHU premises so that participant's details were stored within the University's GDPR guidance. Hard copies of data that were produced for analysis purposes were fully anonymised. Electronic versions of transcripts / data / audio files that were used in the analysis phase were stored on an encrypted device or within SHU password protected systems.

All transcription was done by me to ensure privacy and confidentiality. Audio recordings were not sent via email to a third party and the original audio files on the unsecured device were deleted.

There were also some potential benefits to being a participant in this study. Participants had the opportunity to reflect on their classroom practice and consider their own understandings through the narrative process, something which has been noted as beneficial in a number of similar studies (Frost, 2010, Halai, 2011)

As the study progressed, one ethical issue arose linked to the demands placed on my participants in terms of time. All five participants worked full-time in schools and had responsibilities within their departments either as the study started or as the study progressed. The impact of this was that I had to be very flexible in the timing of interviews and for some participants such as Chris, who changed schools part of the way through the study, there were long gaps between the interviews.

3.7 Chapter summary

In this chapter I have examined the underpinning theory that informs my methodological choice to use the constructivist design of Grounded Theory Method developed by Charmaz (2014) and to generate data through teachers' narratives about their experiences of becoming and being biology teachers. These were obtained through a series of semi-structured interviews. I have charted the development of my methodological approach including my personal ontological journey as I developed this study. I have also given details of the design of this study including a justification of my decisions to use a combination of methodological approaches my decisions about transcription procedures and a consideration of the ethical issues for this study. In the following chapter I provide a detailed description of the analysis process I used with supporting examples.

Chapter 4: Data Analysis

4.1 Introduction and outline of the analytic process

In this chapter I provide details of my process of data analysis. I start with a consideration of the tensions between using participants' narratives as data and the GT approach, and what this means in terms of the presentation of my participants' stories. I present examples of the data to show how I moved from open coding to categories and finally to diagrammatic representations showing my analysis of how data categories relate. Finally, I summarise my interpretation of the data and the themes that I will discuss in the findings chapters that follow. In conducting my analysis, I followed a sequence of procedures typical for a GT approach: open coding, memoing, selective coding and theoretical coding (See Table 4.1). I also followed Charmaz's advice about flexibility and the use of other data distillation tools and produced tables and matrices of responses to allow for comparisons (Basit, 2003). Examples of these can be found both in this chapter and in the appendices.

Table 4.1 Summary of the analysis procedure

Stage	Process	Details / Example page reference.
1	Transcription of first interviews	Section 3.6.8, p. 82 for details.
2	Open-coding first interviews	Example Figure 4.1, p. 89 and Appendix 4, p. 242
3	Additional questions for interview 2	Table 3.3, p. 79
4	Transcription of interview 2	
5	Open coding of interview 2	Appendix 4, p. 246
6	Transcription of interview 3	
7	Open coding of interview 3	Appendix 4, p. 247
8	Matrix of responses against key questions in each interview	Appendix 5a, Tables 5a.1, p. 248, 5a.2 p. 251 and 5a.3, p. 255
9	Revisit open coding	
10	Selective / focused coding of all interviews	Table 4.2, p. 247 and Appendix 6, Table A6.1, p. 263
11	Theoretical coding – construction of relationships	Figure 4.4, p. 100, Figure 4.5, p. 102, Figure 4.6, p. 108 and Figure 4.7, p. 110
12	Memoing throughout to capture	Example can be found in Appendix 7, p.

	ideas.	267

4.2 Tensions between the use of GT approaches and narratives

As I analysed my data, I became aware of a tension between my use of GT to inform the analysis and my aim of using biology teachers' stories. GT requires that the data are fragmented in order to look at patterns, consider how these might be connecting and how they compare across participants, in effect breaking the narratives. I was aware that I had initially set out to tell biology teachers' stories about their experiences of biology teaching and had intended to sequence and present my interpretation of these stories. However, as the analysis progressed, I realised that in asking participants to tell their stories about biology teaching I had also encouraged them to share their opinions and beliefs. As I interpreted the data some clear ideas emerged from my analysis that appeared to be consistent across participants and I began to work with these in a much more thematic way. What resulted was my compromise between wanting to keep elements of my participants' stories and their voices and wanting to explore the themes that were emerging for me. Where it seemed appropriate, I presented the findings as narratives, so for example when participants were sharing their stories about their journey to becoming a biology teacher or their stories of early experiences with biology, for other findings I grouped common responses together thematically while still using the participants' voices by presenting excerpts from the interviews.

4.3 The process of distilling and coding the data: an overview of the process

The first step in analysing the data was the transcription of the interviews from the audio recordings. This was carried out by me and formed an initial opportunity to

interact with the data. My approach to transcription is discussed in more detail in the previous chapter, see Chapter 3 section 3.6.8 (p. 82) After listening to the first interviews and transcribing them I carried out an initial open-coding exercise. This was conducted quickly with the aim of labelling segments of data (see the example in Figure 4.1) The data were initially approached in response segments rather than line by line as my transcription method meant that I had transcribed some filler responses and vocalisations of thinking such as ‘umm’ and ‘err.’

Figure 4.1 An example of a section of highlighted and labelled transcript (Chris, Interview 1).

C: Erm … well the first one was because I thought I'd be a bit clever really, it was just the fact that whatever we do, whatever we teach, it's all about that at the end of the day

P: Yeah (unintelligible)

C: so I just thought I'd just take a picture of that and just say well that's what it boils down to at the end of the day, just an exam paper and that's what we're there to do, teach them the content and maybe, sometimes … that does take away from it a bit because you can't do everything you need to because you've got to make sure … that … you can't expand on stuff as much as, you can't then explore as much as want to because actually that's what we've got to get done, that's what we've got to, that's what we're restricted to importance of exam success

P: Yeah

C: erm … so I took a picture of these ones, these ones specifically just because we tried to do … we did er … these're from another group so it's about dirty hands and not dirty hands challenges / issues with practical work

P: right, yeah

C: and they didn't come out as good as I thought, but they're just exactly the same and I think that that was the thing, if you haven't got the perfect conditions of the laboratories … microbiology just … issues with practical work

P: … can be more confusing than …

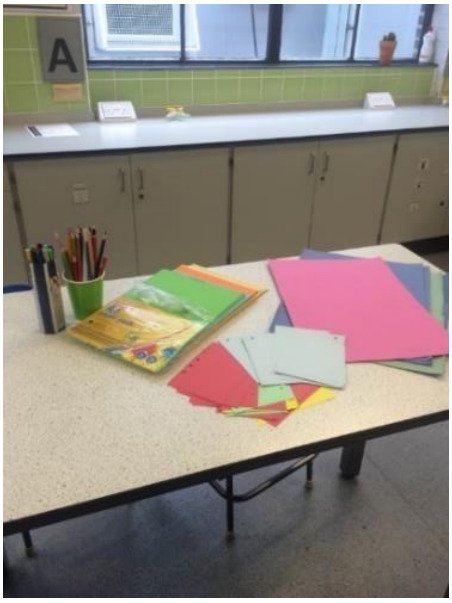
C: Exactly, because you can get this where it's like, I've washed my hands and it's just covered … more than the other one … and it's just because … they've done something wrong … they've not flamed it properly or they've not done something else and you can't go into the detail on exactly how to do … you can do aseptic technique, but in the classroom Limitations of practical work

P: it's limited

C: Exactly yeah, erm, so it's just that was one that I did initially err … oh, this one! That was because what I like to do, and this was something I made, was that sometimes you can't, you can't go out and go to a pond and show them pollution indicators, so trying to make it real which is something I quite like. And I thought, I'll make these just to sort of be like so they've actually got to go and look at some ponds Modelling practical techniques

Some of this initial coding informed the questions for the next set of interviews, for example in the first interview with participant B there was a comment on an image of colouring pencils. (See figure 4.2)

Figure 4.2 Participant image and a section of the story behind the image.



Becky: This! This was more what … how people perceive Biology

P: Right, that's interesting

Becky: Yeah … because I get an awful lot, especially from physics teachers, in particular […] oh, just get the colouring pencils out and I think there is kind of this idea that it's all poster making […] and colouring in and … there is this, yeah there's this stereotype of this is what biology is and I like to, you know again talking about cells, getting them to make large cells and doing something like that but I think that the difficulty erm … of biology is quite often kind of underplayed by other people, other scientists who do think of it as a bit of a soft option.

(Becky, Interview 1)

This prompted me to ask all participants about their perception of how the status of the subject was seen by others.

In many cases my initial codes used descriptive terms rather than using action or process words as suggested by Charmaz, the aim at this point being to simply fragment the data (Urquhart 2013). The open codes were collated as a simple list for

each set of interviews (See Appendix 4, p. 241). It was also important to compare the data so in addition to open coding for each response or partial response I produced a set of matrices of each participant's responses, firstly in terms of the images that they presented and secondly against the key questions (see Tables A5a.1, A5a.2, and A5a.3 in Appendix 5a, p.247). This was another way of approaching data distillation. It allowed me to retain the participants' actual words and also offered a quick comparison across participants allowing me to see common expressed ideas about biology teaching. A disadvantage of only using a response matrix would be that it does not fragment the data in the way that the open coding did, meaning that I could have 'lost' some of the expressed ideas that emerged as the participants elaborated on their responses to specific prompt questions.

These grids formed another element to use in my analysis, following Charmaz's recommendation of a flexible approach with multiple analysis tools. However, I was mindful that the questions used reflected my perspective as the researcher and so were only part of the data to be analysed. At this stage I considered the use of the coding software 'N*Vivo' but rejected its use in this study, agreeing with the points also made by Basit (2003) that the process of coding in this way, for me, felt more abstracted and less intimate. After personally transcribing the interviews, I carried out constant comparison of the data, revisiting the whole interview transcripts several times, as for me it kept my participants' voices alive and allowed me to check for common themes across participants. After the initial open-coding I revisited this stage several times in order to check for any missed ideas. During these subsequent 'passes' over the data I also changed some descriptive codes to more analytic codes, for example descriptions such as 'Others' perceptions of biology' became 'Perceived status of the subject.'

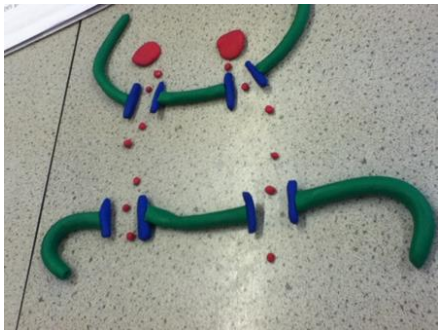
As well as the initial open-coding I also produced a short interpretive account of the first interviews along with some selected images which was presented to each participant. This acted as both a check for participants and the stimulus for the second interview. I gave participants their personal summary to read before the second interview and invited them to comment on whether it was a fair representation of what they had said. For an example of this see Figure 4.3.

Figure 4.3 A section of the interpretive account produced for participant A.

Summary interpretation of Interview 1 (Arron)

As we discussed the images that you had chosen to show me, I felt that a number of issues emerged around your thoughts about biology teaching.

A recurring theme, and the first idea to be discussed, related to the importance of encouraging pupils to model ideas in biology in order to deepen their understanding.



The first example showed an activity involving the modelling of a synapse, but you also discussed using a sequence of diagrams to model enzyme action. Related to this idea you discussed the importance of using analogies to help with understanding - again you particularly flagged up the fact that some concepts in the subject are hard to visualise.

You also showed an example of a pupil producing a creative model - the skeleton cake.

For you this highlighted an important idea about allowing pupils for whom literacy might be a limiting factor to demonstrate their understanding and enthusiasm. You felt that a creative approach to demonstrating learning was something that should be considered more, and that exams, however important, were only part of the approach needed to show pupil attainment.

Listening to you I felt that a second important aspect of your ideas about biology teaching was the idea that concepts should be related to 'real-world' issues. You explained that one of the key drivers for your personal interest in biology was a curiosity about the incidence of sudden cardiac death in sports people. This led to a determination to research the condition and resulted in an exemplary piece of work for your dissertation. Much of your interest in biology stems from this and you really enjoy the anatomy/human biology aspect of the subject. You also feel that the link between understanding biology and leading a healthy life is crucial, and you enjoy the cross-over between academic biology and personal, social and health education topics. To me it appears that it is really important to you that the subject of biology has a positive impact on pupils' lives that reaches beyond academic achievement.

You also felt that examination success was important but felt that exams needed to be constructed carefully and that there needed to be a degree of application of

understanding in the questions. You felt that your involvement with examination boards and writing questions allowed you to influence this aspect of biology teaching.

This led on to a discussion about CPD in its broadest form. You currently enjoy the challenge of being on the teaching advisory board for the publication 'Big Picture' and have used this as an opportunity to meet with other teachers and discuss teaching and examinations. This idea of continually adding to your knowledge and expertise was revisited when you talked about the use of new technologies in biology lesson.

The second phase of analysis involved ‘focused’ or ‘selective’ coding. The ‘focused’ or ‘selective’ coding was carried out by grouping the initial codes into categories. At this point the names of the categories were given conceptual rather than simply descriptive labels and I used language that coded for actions and processes (Urquhart, 2013, Charmaz, 2014). In this phase I was very aware of the ‘insider’ aspect of my position (see Chapter 3) and the language of the selective codes was based on my own interpretation of the participants’ responses. I used memoing as a way of capturing both data and initial thoughts throughout this process. Memoing allowed me to capture initial ideas about how the codes were relating to one another and to cross reference themes that were emerging against all five participants (Charmaz, 2014). An example of a memo can be found in Appendix 7 (p. 267). As part of the memoing process I also noted any aspects of my own story where I felt a resonance with what was being said. I had initially considered recording myself and transcribing the story but in view of time pressure I decided to write instead. I set myself the task of just writing as though I was telling the story, not going back to correct or edit, in order to capture the memories in a similar way to my participants. Examples of these personal stories can be found in the introduction chapter and at the end of my thesis, other examples can be found in Appendix 5b (p. 261). An example of moving from open codes to selective codes and then to categories can be seen in table 4.2.

Table 4.2 An example of the process of moving from open codes to analytic codes and categories

Example of Data	Open code	Selective code	Final Category
A: So, er … the plasticine in this, image one, is very much the idea of trying to get pupils to model something so this, this is a synapse, P: Yeah A: we're looking at the neurotransmitter moving through the channels … and what I like to do is to try and get them to make little movies with it	Using models and analogies	Teaching for understanding	Teaching for understanding
C: and I think when I was … when we were starting to look at it … when I was starting to think about, well why can't the kids apply this knowledge? I was thinking that the way you should do it is teach them the content, practice the content and then practice applying it	Application of knowledge	Teaching for understanding	Teaching for understanding
E: you have to cover this, this stuff and actually it's possibly not the most interesting for some kids P: Hmm E: some of it will be and each one's individual and there's such a breadth P: and it's such a snapshot as well E: Yeah. But it does cover, it does seem to cover such a huge range of topics that you barely seem to skim the surface of anything before you	Wide range of content	Identifying barriers	Dealing with the challenges of the subject
B: Okay, so the first one is just that I find urm … an area where people really, really do struggle	Difficulties of technical vocabulary	Identifying barriers	Dealing with the challenges of the subject

with the language that they have to learn, and so for example I was teaching this lesson on Friday to my triple group and the first thing I said to them was, you know, right, we've got glucose, we've got glycogen, we've got glucagon. They're all very different but you need to be able to do that and I find that a real, real problem is them being able to learn this huge array of vocabulary and be able to use it the way that the examiners expect them to be able to use it. So, the other example's obviously homozygous, heterozygous and all of those … and it's just that the words are so similar			

The final analytic phase was to look at potential relationships between the categories, to reassemble my data and build a story about how the participants appeared to be constructing meaning in specific situations. I approached this analysis of potential relationships between categories by using my initial research questions as a framework, allowing me to construct my analysis around these broad concepts:

What are teachers' expressed beliefs about biology teaching?

What are biology teachers' perceptions of how previous experiences are influencing their beliefs?

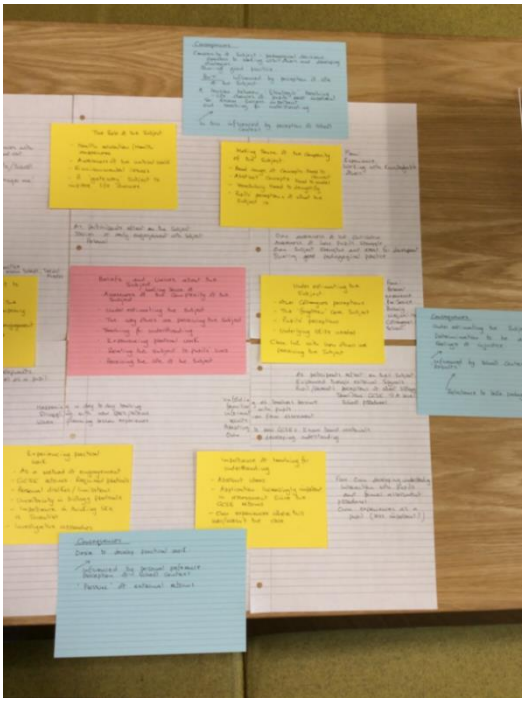
What are biology teachers' perceptions of how they can implement their beliefs in the classroom? For this question I was looking for my participants' expressions about what was influencing their pedagogical decisions.

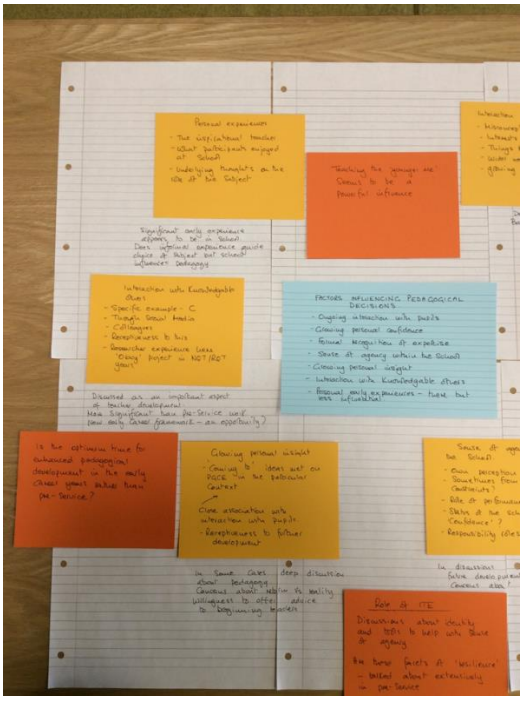
I initially used cards to construct relationships between analytic codes, categories, and their relationships. I found that the physical process of arranging and trying to connect categories allowed me to change things around and reconsider relationships (Urquhart, 2013, Charmaz, 2014). The process was particularly useful in consolidating my thinking about which aspects of the coded data represented key categories. For example, 'Reflecting on personal experiences as a pupil' was initially a sub-category but as I arranged and rearranged the cards, I realised that participants were mentioning this idea in relation to a number of their beliefs about teaching the subject. For me there was something about being able to physically move information that helped clarify my ideas. I captured these maps by photographing them (see figure 4.4 for an example). Charmaz refers to this as 'theoretical coding,' but I found the term 'reflective coding' (McCaslin & Wilson Scott, 2003) to be a useful alternative as part of my analysis was to reflect on my own

experiences and think about how these might connect with the evidence from my participants. This stage of the work represented the theory building that would form the basis for the discussion chapters that follow. Urquhart (2013) suggests that there are 4 components in theory building and I used these as my guiding framework in the analysis process:

- A narrative framework, the means of representation – this comes in my discussion chapters and includes examples of my participants' voices. Although I have chosen to introduce my participants with stories most of the data is presented thematically in my findings chapter.
- The construction of core categories from the data
- Statements of relationship which are initially represented in my relational diagrams (see Section 4.4, p. 101 onwards) and then elaborated on in the following discussion chapters
- Scope: the generalisability of the theory. In this case I am arguing for resonance (Conle, 2000) and abductive reasoning (Charmaz, 2014) taking the position that the data will yield plausible conclusions that will inform professional practice and, although it may not be widely generalisable, it may be relatable to others in similar contexts.

Figure 4.4 Examples of part of a 'messy' construct for relational analysis.





The initial construction of relational diagrams used four relational questions identified as a means of connection.

1. What does this actually look like? (Using the participants' own words)
2. When is this happening / being evidenced?
3. How does this appear to be influenced?
4. What is the consequence? i.e. How are the participants making meaning of this? (Adapted from McCaslin & Wilson Scott, 2003)

Charmaz (2014) suggests that diagramming is an important aspect of Grounded Theory analysis and can help by producing concrete images of ideas, showing the categories, their components, and their relationships. She argues that '*You can use maps to form your analysis as well as report it*' (p. 220). After capturing the final organisation of my relationship analysis, I converted the photographs to relational diagrams under the broad headings of my research questions. These relational

diagrams can be found in the sections that follow and informed my thinking in presenting the findings in Chapter 5.

4.4 Selective coding and category formation in detail

4.4.1 What are biology teachers' expressed beliefs about teaching their subject?

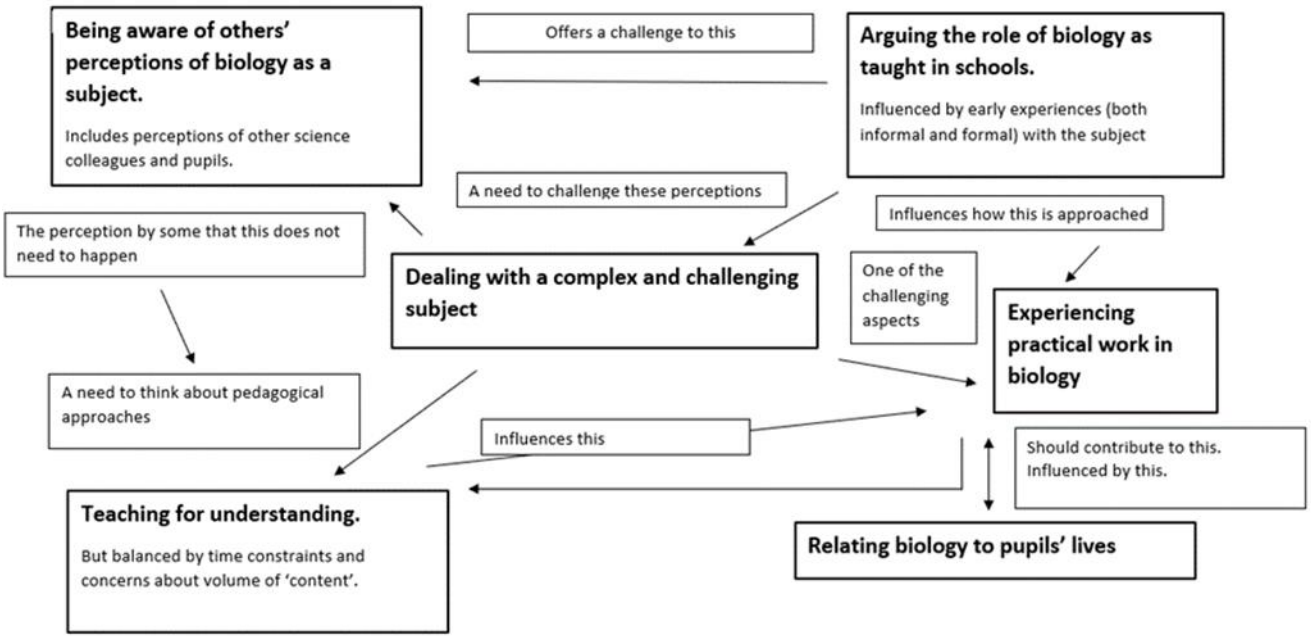
The richest source of data addressing this question was found in the first round of interviews as the participants explained their thinking behind the images that they presented, a number of their ideas were revisited in subsequent interviews and for one participant their responses became much more detailed in the final interview. I discuss this in the following chapter. In Table 4.2 I give an example showing how I grouped open codes into selective codes and then into final categories. When looking at the data in this stage it became clear that in many cases the open codes were redundant, with several different codes actually offering descriptions of similar ideas. These were combined to form the selective codes. I then looked at the themes or categories that appeared to be emerging from the data. The full list of selective codes can be found in Appendix 6 (p. 263).

The key categories constructed by my analysis of the data on teachers' expressed beliefs and values about teaching the subject were:

- Teaching for understanding
- Dealing with biology as a challenging subject
- Experiencing practical work
- Relating the subject to pupils' lives
- Underestimating the subject
- Explaining the role of the subject

Figure 4.5 below represents a formalised relational diagram showing my initial thoughts on how these categories might be linked.

Figure 4.5 Relational diagram showing participants' expressed beliefs about teaching biology.



In Figure 4.5 I see the concept of biology as a complex and challenging subject at the core of participants' beliefs about the subject, with key challenges being around how to make the subject relevant to their pupils' lives and to teach for a deep understanding of ideas. They echo some of the concerns in the literature (Abrahams & Millar, 2008) about the use of practical work, particularly dissection, which they saw as unique to biology as a subject, feeling that it was a way of engaging pupils but that it may be contributing to misconceptions in some cases. The diagram shows that others' perceptions of biology, as the science with less rigour, was a cause for concern and a perception that they felt the need to challenge.

The evidence that informed the category 'Teaching for understanding' included several expressed beliefs, many of them common across all the participants, about important pedagogical approaches. These are summarised in Table 4.3 as they will inform the discussion in the following chapters.

Table 4.3 Expressed ideas about pedagogical approaches.

Example of data	Expressed idea about pedagogy
A: So, er … the plasticine in this, image one, is very much the idea of trying to get pupils to model something so this, this is a synapse, P: Yeah A: we're looking at the neurotransmitter moving through the channels … and what I like to do is to try and get them to make little movies with it	Modelling and the use of analogies as a key approach
A: … you can't have a good study of biology without actually having a fundamental understanding of chemistry because at a physiological level …everything is, is really, is chemistry B: No … they don't make those kinds of connections in that it doesn't seem like something that's really important … they need to be learning D: and again, giving them the experience of, again, not just biology but other science things that they're going to enjoy.	The importance of connecting concepts
A: and if you can't visualise, I don't think you can apply... the students just don't have that... that skill set really D: So, it was taking biology and putting it in a different situation. Because one of the ways in which the assessment is changing is a lot less fact basis … more applying your knowledge P: Yeah D: So, one of the complaints I get all the time is ... I teach about cells and the differences in the cells and the exam question'll be 'Look at this amoeba' and then they freak out instantly	Ensuring that pupils can apply their understanding
A: ... I think sometimes when we do practical in biology if we're not 100% clear about what's going on P: Yeah A: we're actually doing... leading to... P: misconceptions? A: misconceptions and we do more harm than good. Err so biology is then very much	The importance and challenges of practical work

reduced to chalk and talk at its worst so the idea of modelling something err… very much and the use of lots of wacky analogies B: what do you have to do to, you know, I haven't got a picture of it there but things in the past where I've made err… cells out of sweets so they've actually got all the different sweet parts of different organelles and then you can actually eat them all and just something to try and make it memorable C: Yeah. The only thing is sometimes practicals just don't work and I think personally, I don't want to talk bad about them, but I do feel that our technicians are much more able to give advice on chemistry and physics practicals than biology. E: Because you can't, you can't go into the detail, you can't do the practical that you want to do because you seem to be P: Yeah E: you've only got half an hour and you've got to move onto the next thing or	
A: Yeah, yeah. So, I... so that is very much what I still like to do... to teach... and the one bit I suppose I'm really passionate about is the heart but funnily enough if you asked me to do a dissection of it, I'm utterly useless P: Right A: I can't do the anatomy really P: Right, yeah A: Because it's a lump of meat on a tray. I can't see the different structures. B: This is an ox heart, it's absolutely massive, look at it, you've all got your little ones erm … that's one of the best lessons I've had with that class because they were just so engaged, they were so focused on it and I just … I really, I love doing dissections P: So, talk me through D: Right, so I chose image one … erm … that's a dissection we did … just last week D: so that's why I chose it. Because dissections engage them straight away because … they're doing something that they would probably never do at home or in, certainly	Dissection as a specific example

in any other subject E: It is a heart dissection. I think the kids need to get stuck in, need to see things for themselves. They need to be able to cut a heart up and find the bits inside of it themselves, without me having to say anything to them. Because I think if you just talk at them a lot … it doesn't go in	
A: and your GCSEs do matter but only to get you to the next stage C: so I just thought I'd just take a picture of that and just say well that's what it boils down to at the end of the day, just an exam paper and that's what we're there to do, teach them the content and maybe, sometimes … that does take away from it a bit because you can't do everything you need to because you've got to make sure … that … you can't expand on stuff as much as, you can't then explore as much as want to because actually that's what we've got to get done, that's what we've got to, that's what we're restricted to	Teaching for exam success

4.4.2 What are biology teachers' perceptions of the way in which previous experiences with their subject have influenced their beliefs about teaching biology?

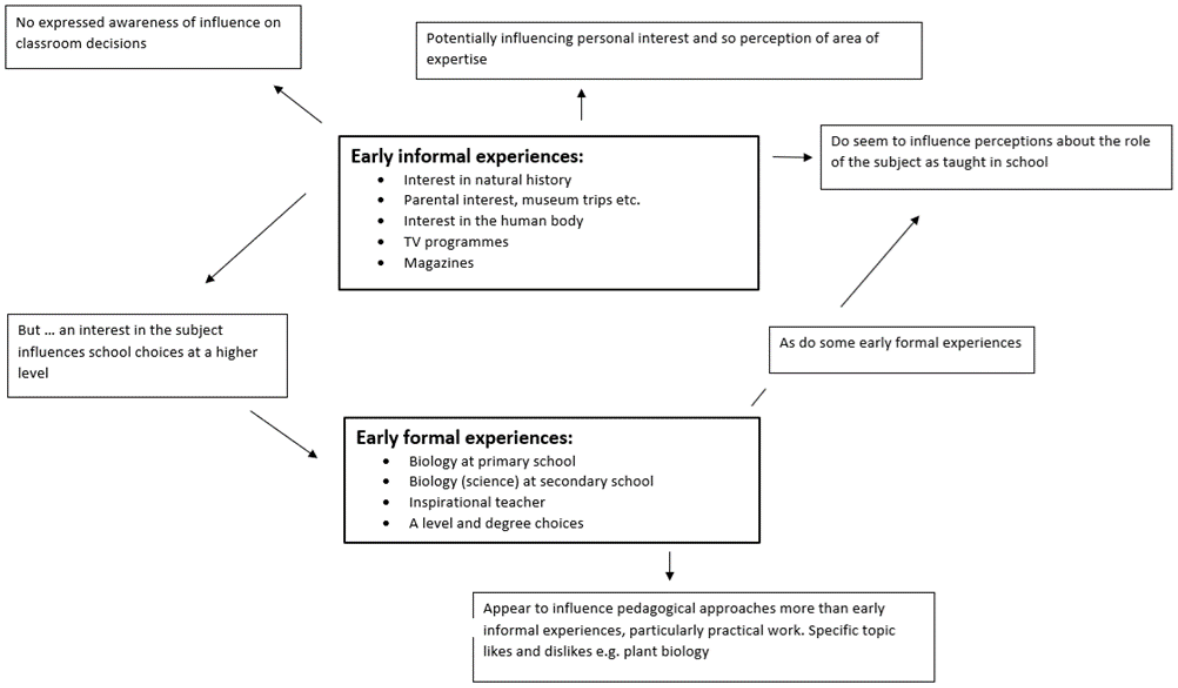
The second area for analysis involved looking at the data around my participants' perceptions of how early experiences had shaped their beliefs. Participants discussed both their early informal experiences this included experiences outside formal education such as visits to museums, an interest and interaction with natural history and an early interest in how the human body works as well as their formal experiences in school and university as learners of biology themselves. A comparison of responses across participants can be found in table A5a.2 in Appendix 5 (p. 251).

The key categories identified were:

- Early interaction with the natural world
- Parental influence
- Personal interest in the human body
- TV and magazines
- Biology at primary school
- Biology at secondary school
- Influence of an inspirational teacher
- A-levels and beyond

Using the participants' responses, I constructed another relational diagram, Figure 4.6.

Figure 4.6 Relational diagram of teachers perceptions of the influence of early experiences on beliefs about biology teaching.



In Figure 4.6 above I have attempted to show how I interpreted the way in which previous experiences with biology are related. For my participants, early informal experiences were clearly the start of an interest in the subject. For some participants this was an interest in the natural world but for others it was an interest in the human body. This interest clearly encouraged them to continue with a study of the subject, but they also appeared to contribute to an underpinning belief in why the subject was important for pupils to learn about. Their own formal experiences of learners of biology appeared to be having much more impact on their classroom decisions, with practical work, in particular being highlighted as something that many of them enjoyed. Interestingly, several of the participants told stories of particular teachers that had influenced them.

The final grouping of data was to address my third research question: what are Biology teachers' perceptions of how they can implement their beliefs in the classroom? As I interacted with my data this question became transformed into something wider:

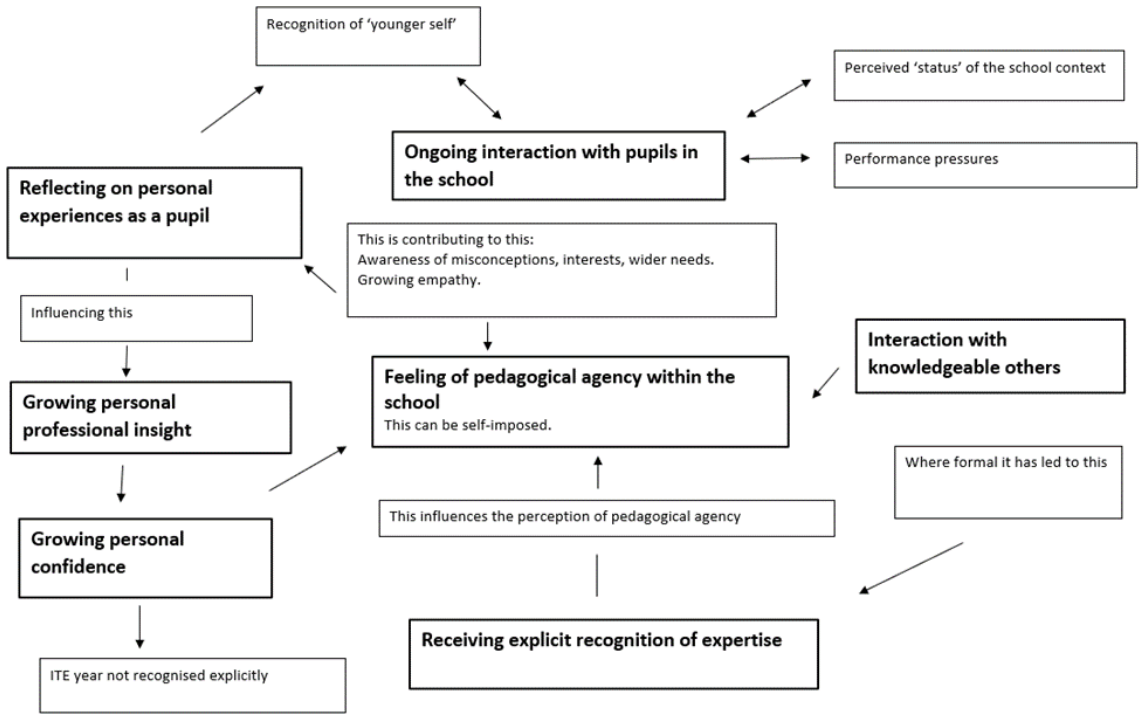
4.4.3 What are biology teachers' perceptions of how they can implement their beliefs in the classroom?

From my initial open coding and selective coding, I identified the following categories.

- Growing personal professional insight
- Feeling of pedagogical agency within the school context
- Growing personal professional confidence
- Receiving explicit recognition of expertise
- Ongoing interaction with pupils
- Reflecting on personal experience as a pupil

In the same way as before I constructed a 'messy' map using cards that allowed me to think about the relationships between categories before constructing a relational diagram, Figure 4.7.

Figure 4.7 Relational diagram of factors influencing pedagogical decisions in this study



In this diagram I have attempted to show how I understood the various factors that are acting to influence the teachers' developing personal practical knowledge, shown down the left side of the diagram. One of the factors that emerged from the data was the influence of a recognition of the teachers' own personal educational experiences as they related to the pupils' response to being taught biology. Central to the factors that teachers felt were influencing their classroom decisions was their perceptions of how able they felt to enact their decisions, their perception of their pedagogical agency within the school context. Their feelings of pedagogical agency appeared to be greater when relationships with colleagues led to either a recognition of personal expertise or a sharing of classroom practice. The school and wider context appeared to underpin these feelings. Where school offered opportunities for recognition and

collaboration feelings of pedagogical agency were high. Where there was no explicit recognition from the school assumptions were made about what may or may not be possible in the classroom.

4.5 Summary of analysis

Having analysed the data I felt that my findings could be grouped into four key areas of interest that related to my research questions. Two categories related to my first two research questions and two themes related to my third research question. In the next chapter I will discuss these in more detail and then, in Chapter 6, discuss themes emerging from my analysis of the data in relation to relevant literature.

These will form the focus for a discussion of findings in Chapter 5. They include:

1. **Beliefs about teaching biology.** This was based on one of my initial research questions. It formed the starting point for my conceptualisation about the factors that the participants perceived were influencing their classroom decisions.
2. **Previous experiences with their subject.** This linked to the second of my research questions.

My final research question was to examine teachers' expressed perceptions of how they can implement their beliefs in the classroom. Two key areas of interest arose from my analysis in response to this question.

3. **Pedagogical agency**. This refers to the perception that participants had of their ability to act on their pedagogical thinking.
4. **Relationality and the development of teacher knowledge.** This explores the influence of developing relationships with pupils on pedagogical decisions,

as well as the influence of colleagues, the biology / science teacher community and expert classroom support.

Having completed my analysis, I reconsidered some of my plans. Initially I had planned to present narratives from my participants to illustrate my findings, however, after the analysis it became clear that the teachers were expressing several common ideas in relation to my first and third research questions. They not only told stories about their experiences of biology teaching but included wider reflections on their thoughts about biology teaching. I decided therefore to present short narratives to illustrate participants' journeys to becoming biology teachers and their early experiences with the subject but felt that a more thematic presentation of participants' responses allowed me to consider the areas of interest that I had identified.

4.6 Chapter summary

In this chapter I have described the details of my analytic procedures, including a consideration of the tensions between a GT approach and the use of narratives, and I have illustrated these with examples. I carried out initial open coding of the data and these codes were then grouped into concepts which I refer to as categories. As a way of carrying out constant comparison I produced matrices showing each participant's response to particular questions. I used memoing to identify relevant literature to use and the construction of diagrams to look at the relationships between categories and areas of interest in the data. The data suggested four areas of interest addressing my research questions. These are summarised in the previous section. In the next chapter I present my findings, elaborating on each of these four areas of interest in depth.

Chapter 5: Findings

5.1 Introduction

In this chapter I present my findings using my interview data. My choice of how to present the data at the beginning of the chapter is influenced by life history approaches (Goodson & Sikes, 2001, Clandinin & Connelly, 2000). Firstly, I have combined stories from the interviews to construct a short biography of each participant first presenting their stories of their journey to becoming a biology teacher and then presenting their stories of their early experiences with the subject. The choice to present these initial biographies before looking at the data more thematically was informed by my relational approach to the interviews (Riessman, 2001, Gubrium & Holstein, 2003) and also my awareness that GT analysis fragments the narratives. Riessman talks of the potential for 'dehumanising research practices' (2001, p. 695) and I was aware of the risk of falling into a subconscious positivist approach by simply identifying data excerpts related to themes so, although it was necessary to fragment the data in order to code for themes, I wanted to present an initial picture of each participant holistically. I wanted the reader to share a small part of my participants' stories and empathise with them and it also felt like a respectful treatment of participants who had given their time and shared their stories with me. In presenting these stories I have created a sequence that does not always match the order of the interviews. I am aware that having organised the initial stories to supply a plot that can be followed, a process which included the selection of excerpts to include and the reordering of these excerpts, I am bringing my own interpretation to my participants' words and have risked losing aspects of my participants' emphasis in favour of a linear narrative (Riessman, 2001).

In Sections 5.4 to 5.8 I present the data thematically under the headings of the areas of interest linked to my research questions that arose out of my data analysis: teachers' expressed beliefs about teaching; teachers' perceptions of the way in which previous experiences with their subject have influenced their values and beliefs about teaching biology; teachers' perceptions of their pedagogical agency; and relationality and the development of professional subject identity. Response matrices for the key questions asked in the interviews which summarise participants' responses to questions asked can be found in Appendix 5, Tables A5,1, A5.2 and A5.3 (p. 248, 251, 255)

5.2 The journey to becoming a teacher

The following stories based on interview data serve to introduce my participants by giving an indication of their stories of becoming biology teachers.

> ***Arron****: My parents were fabulous and very, very supportive but I was definitely ushered down the medicine route and I didn't want to do the medicine route … and u then I ended up on a, I didn't get the grades for medicine, thankfully I didn't get the grades for medicine, I got into university more on the strength of my sport than my 'A' level results […] and as a result of that I was playing a lot of sport I did an awful lot of coaching and there was, you know sports science has always interested me but you know it, really I want to be a history teacher if I'm completely honest with you […] and so that … the sport led to sports science which led to coaching because I was able to do it and I had the right connections through colleagues in my sport I was able to get involved with the local governing bodies as well […] and just built up a … so many good, I suppose connections to the teaching world with... teaching*

became the natural step […] and my Mum was a teacher she always said do a PGCE in a science and then you can always move into PE, because PE was my first, initial thought.

(Interview 1)

***Becky**: Erm … so the initial plan when I was at school was to be a doctor … kind of going down the medical route type thing but when I very quickly discovered that I wasn't going to put anywhere near enough work in order … to get the grades necessary for that… so I actually started applying for English […] that was my initial. Started doing err … started looking for English Literature degrees but again didn't really put enough work in and I'd already got all the sciences for the A' levels erm … which didn't really lend itself very well to English … so when it came to actually going to university to go actually you know, I'm not going to do English, I'm going to do Biology because I love Biology, loved my Biology at A' level, got a B in it err … I'm going to do that, so I went and did, like, a semester of Biology, actual Biology […] before then deciding that I didn't want to do that either […] There were an awful lot of changes. But er … I done a lot of work with erm … teaching, so working as a TA … working with my err … my parent's school and things like that and my mum said to me … why don't you become a teacher? And I had all of the science background and I err … had all of that and I then started applying to actually become a science teacher and obviously it was a really natural progression when we had to specialise … that biology would be the one because that's the one that I enjoyed most, that was the one that I had err … most experience in and that was the one that I was more passionate about.*

(Interview 2)

***Chris**: (I) did biomedical science and just realised that I didn't like being in the lab at all and wanted to do something different … Erm … and then, sort of, remembered back to teaching biology, and I was a bit like … I'd like to do that, see what it's like … went to a couple of lectures at uni and erm … then I was right, I'm going to do something about observations and went to (a school) in … Erm … and realised that actually yeah, I do want to give this a go and that was it really. Just … because I just loved biology and just loved science in general and I think that love had come from the teachers here and I think that just, sort of, underpinned everything that I'd done erm … prior to that and I realised that I didn't like being in a lab, didn't like that setting so I wanted to do something a bit different, a bit more out of my comfort zone*.

(Interview 2)

***Dan**: I liked just to sit there and listen … to the teacher just waffle on about anything … I really liked that and then I wasn't even one of them kids who always wanted to do practical, I weren't bothered … I just kind of listened to them … learning new stuff … so that's what my teachers did.*

P: at what point did you think … teacher?

Dan: Always … year 9 I decided I wanted to be a science teacher

P: So, it was about talking about science

*Dan: Yeah, I distinctly remember going to a Miss P*****, my science teacher when I were in year 9 and saying, right, how do I go about … how do I become a science teacher? […] and, actually, what she said was what I did, I*

got a biology degree … then I did a PGCE and then I became a teacher and that's always been my goal.

(Interview 2)

Emily**: (Laughs) Well I always, I remember, you know when you get asked as a kid what do you want to do when you're older? From about 3 years old I wanted to be a vet … and I … spent as much time as I could with animals … and worked on a riding yard when I was 15 … erm … I got work experience in a vet's practice that I … stayed there for 3 years … just turning up every Wednesday to erm, watch consultations and, and help out and stuff and it got to the point where I were doing my A levels that I realised that I wasn't going to get the … 3 As that I needed … so … erm … I had to decide on something else and the only, sort of, logical one for me was zoology with my obsession with animals. Erm … so I went to Bangor University … and did zoology … and I still didn't really know what I wanted to do … I kind of looked at various different things and my Mum worked in teacher training for W***** and because of her that idea of, sort of, teaching got into my head and then I just thought I'd give it a go […] It was very … I don't remember actually thinking I'm going to change my … mind. […] like something that worked its way into my head I think in final … year of university and then, kind of, stayed there and I got some experience in schools and thought […] this is what I want to do … went for my PGCE.*

(Interview 2)

Interestingly four out of my five participants tell a story of either not liking their first choice of career or 'failing' at an initial career path before deciding to become a

biology teacher. In three cases this involved an initial ambition in medicine or veterinary medicine. Only Dan had always had an ambition to be a biology teacher and had planned his qualifications and experiences with that in mind. I reflected on my own journey in the introductory chapter, and it has similarities with most of my participants, an unsatisfying job and a chance set of circumstances that led to the discovery that I actually really enjoyed teaching.

5.3 Early experiences with the subject

> ***Arron**: err …I don't know, I, I guess I was looking at … my Mum and Dad always took me to museums, always took me to things, so I always kind of knew all that stuff anyway […] I had that … that natural …I don't quite know how to describe it …I think … it's not 'clever' because I don't think I had to do anything particular to achieve that much, but I had acquired that knowledge of … that sort of science … from a relatively early age because we'd gone to places like Eureka, we'd gone to the Discovery Museum in Manchester and you'd seen these things. […] Mum was able to talk to me about it, Dad was able to talk to me, and explain to me about it … and so it made something I … I just had a natural bent towards it […] just acquired it over the years, just looking in books that Mum had in the house, so you gradually, gradually picked it up and …*
>
> *… I don't think I was ever really a natural scientist, I … at school when I did my GCSEs I did well in, I did well in all my GCSEs but I think if I'm really honest with myself I wanted to do humanities but I allowed myself to be talked out of it by various people, they thought, I was a young lad from the D***** V***** who got six As I was supposed to do medicine … because that's what*

they thrust you into … in those times. […] So, I did Maths, Chemistry and Biology at A-level. Didn't really enjoy … to be honest I didn't really enjoy A-level Biology … absolutely hated it err … didn't really get on with A' level Chemistry, struggled with the Maths and wanted to play more and more football […] and also if I'm honest at that point I realised I didn't want to do medicine … because I just didn't like it … But because I was doing the coaching awards and playing a lot of football I did, I did enjoy the physiology, especially the sports science …. finding out about how our body was responding to changes in the exercise really …

(Interview 2)

***Becky**: Yeah, so I was always really good at school, at science at school and my dad was like this mad twitcher type person and so he used to take me err … used to like, used to go out to, like the Outer Hebrides to look at all the wildlife … and all of that so I think I had that from quite an early age far more than, than any of the other sciences […] but erm … Biology was always my favourite I think it's the wildlife kind of thing.*

… I had a really, really good teacher at A' level as well, a really great science teacher at A' level who was just so engaging and so enthusiastic and I … 'cos I really struggle to actually think of any of the content … that I did erm …

I think I really remember the teacher, and I think we actually did quite an unusual course because I remember we did err … we did all sexual reproduction at A-level […] Yeah, it's not overly common, not even then, so we did a slightly, kind of, obscurer thing and I found that quite interesting. I mean, I do remember absolutely hating the Krebs's Cycle …

(Interview 2)

Chris: *I think it was just here really (current employing school which was also his school as a pupil) … like I'd never really been, I don't think I was really interested in it in primary school, and there wasn't anything outside of that.*

*[…] this is really why I … started the love of biology, two of my teachers that are still here, erm … absolutely, were, like, fantastic teachers and erm … D** who was my teacher at the time is now head of science […] He was a fantastic err … biology teacher and then erm … then P*** S**** who's actually one of my colleagues, he's leaving this year, he's retiring … so both of them really were what started me off,*

… I'll tell you what it was, because when we moved into the new school … that was when we'd got all the brand new labs and there was a lot of … because when we were in the old school it was all like wooden labs, it was all rubbish facilities … so then when we came here we had these brand new spanking labs […] and it was one of those things, like oh my God, this is what science is … and I think it was that sort of, surprise of seeing everything new, so I think it was more year nine to moving into GCSE years was probably where it started, and then A-level erm …just again, I was like, I was they called them like science, I can't remember what they were but they called them science co-ordinators, like students who were helping out with science and that sort of thing…

(Interview 2)

***Dan**: … that it was the biology of the body … that I quite liked and were quite interested in … and all the fascinating things … and it kind of … built on from there. […] Yeah. So, David Attenborough was always a … a feature of, you know, Sunday nights … and that were way before school … and then the … I can remember my mother getting me a subscription magazine, you know weekly or monthly magazines … where you get a little bit every time … and it was the body one and it was … and you get a different organ and put it together […] so she signed up to that and I got that because I loved it and … and I remember another … getting the dinosaur one … so actually, yeah, thinking about it, it was way before secondary school.*

[…] and my primary school level was quite high I think I got 5 in it … and 3s in the rest … levels and … yeah so … it were mainly the teachers and again the facilities we had were really good … now it's old but back then it had just been built they'd had their science block just built […] well, we had this brand-new building meaning the place that I learned were much better … and the equipment they had and it just … you know … it just fascinated … and as a kid it were just really …does that make sense?

(Interview 2)

***Emily**: I think I was always interested in animals, I don't know where it came from I know my Mum's told me stories of when I was, you know, going on holiday to Scotland when I was little and going and seeing reindeer in Scotland … and nobody could get near them so I ran across the field and was sat in the middle of this herd of reindeer […] and things like that I think I've*

always just been … obsessed with animals … as I'm sure … (indicates lizard habitat and animal images in classroom)

I think it built on it. I remember doing, you know, the stuff you did at primary school where you go pond dipping […] and I remember my teacher, 'cos we used to go down, you know, into the local park and look at leaves […] and all those sorts of things, so I do remember it, kind of, crossing over … but that obsession was kind of, was always there, I think it always would have been. […] And I always … I always enjoyed school, I never didn't want to go

(Interview 2)

These stories suggest that most of the participants had some degree of early, informal experiences with biology. A number of them told stories of an interest in the natural world either through parental interest or exposure to natural history programmes, museums and magazines. Chris was the only one who could not remember any experiences like this and felt that his interest in the subject came much later when he was at secondary school.

Four of the participants had positive stories to tell about their formal experiences with biology, with Chris, in particular, citing his experiences with staff at secondary school, which is now the place that he works as a teacher. Arron is the exception. He did not feel that his experiences of being taught were negative, but it is clear from this initial excerpt and from things that he shares in later interviews that he recalls feeling slightly coerced into the choice of sciences.

A number of previous studies have explored the impact of early subject and school experiences on beliefs (Muchmore, 2001, Estola et al., 2003, Johnson, 2010, Halai, 2011, Pritzker, 2012) and several of these highlight how formatively significant early

experiences appear to be negatively or emotionally charged (Frost, 2010, Watson, 2006, Pritzker, 2012). Sometimes these stories of failure or trauma are interpreted as motivation for practice that is 'redemptive' producing 'something better from suffering' (Watson, 2006, p. 481) but sometimes the stories are used to understand identified difficulties with practice (Halai, 2011).

Although most of the participants in this study did tell stories of their early informal experiences with biology the links between these and their classroom approaches were more indirect than suggested in earlier studies (Smith, 2005). These early experiences with biology clearly reflect an early interest in the subject, either through an interaction with the natural world or an interest in the human body and were influencing the choice of subject at A-level and undergraduate level.

Before discussing the impact of early experiences further I will consider my interview data on beliefs and values about teaching biology.

I will now consider findings linked to each research question.

5.4 Teachers' expressed beliefs about teaching biology

There were a number of common beliefs about biology identified by the participants, and these will be examined in turn. These were:

- biology as a complex and difficult subject
- others' perceptions of the subject
- tensions linked to teaching for understanding
- the role of practical work
- relating the subject to pupils' lives

5.4.1 Biology as a complex and difficult subject

The first commonly held belief was about the complex and challenging nature of the subject. This is particularly interesting in light of some the research reviewed in Chapter 1 which suggested that biology can be perceived as an easy option compared to the other sciences. However, the participants in this study highlighted some of the issues raised by Osborne (2007) around the breadth of the subject and the fragmented nature of the curriculum in secondary schools. Often this was commented on in relation to the other science disciplines, so although initially not explicitly commented on by most participants there appeared to be a tacit awareness that there may be comparisons with the other sciences. As Emily commented:

> *I think the only thing is that it's such a broad topic, isn't it? … you've got such a range of … stuff to cover that your areas of expertise aren't necessarily …*
>
> (Emily, Interview 3)

This breadth of topics under the subject label of biology appeared to have implications for personal expertise and preferences. When asked about how the participants saw themselves in terms of subject expertise:

> *Now? Yeah. Now, yeah, Jack of all and master of none I think is probably the word in terms of biology educator, because we do cover the vast amount. I'd still see myself as a physiologist …*
>
> (Arron, Interview 2)

Before admitting:

> *… I suppose with an interest in a bit of genetics and a bit of general physiology. They're … I don't … I don't know, not for one minute am I a*

botanist, not for one minute am I an ecologist. So, I … I … I don't know what a pure biologist is

(Arron, Interview 2)

Another key aspect of the challenges presented by the subject included the extent of new, technical vocabulary that can be encountered by pupils in lessons, for several participants this was one of the first things mentioned in the initial photograph-based interview:

Okay, so the first one is just that I find um … an area where people really, really do struggle with the language that they have to learn, and so for example I was teaching this lesson on Friday to my triple group and the first thing I said to them was, you know, right, we've got glucose, we've got glycogen, we've got glucagon. […] a real problem is them being able to learn this huge array of vocabulary […] and it's just that the words are so similar

(Becky, Interview 1)

Participants also noted that although there is a huge breadth of content there is also repetition in the curriculum and it is not always immediately obvious about how the concepts progress in terms of conceptual demand:

… in the current curriculum, through to year 13, and really apart from the odd little bit in year 13 it actually doesn't get any more difficult … or really get any more complicated than it was in year 9.

(Arron, Interview 1)

This is an interesting contrast to Emily's statement about complexity and represents another challenge particular to the subject in that certain concepts do not necessarily

get more cognitively demanding but include greater and greater detail and often further specialist vocabulary.

A number of concepts in biology were also identified as being abstract and very difficult for pupils to visualise:

> *… do you know, I was describing the central nervous system to them, it's like the A1 and the ganglion off it as the slip ways … because how else do you visualise something that is ridiculously small yet so fundamental …*

(Arron, Interview 1)

There was also an acknowledgement that although pupils often chose to do biology as a single science at A-level to broaden their qualification profile there was often little consideration of the underlying chemistry and physics principles necessary for good understanding:

> *… they can do biology at GCSE because it, it's pretty easy and then the jump into A-level requires actually a working knowledge of chemistry as well as what you think of as biology and a reasonable knowledge of physics […] that's […] ridiculously hard, especially if you've got a child who isn't a scientist, who's gone 'right I'm going to do, I'm going to do art, I'm going to do French, I'm going to do English Language and I'm going to do, I'm going to take Biology because I want to do a Science, I want to keep my options open.'*

(Arron, Interview 2)

There is an interesting contradiction in the participants' responses: they all identify it as a subject with conceptually challenging content making it a 'difficult' subject to understand but also comment on the fact that there is repetition in the curriculum and

that GCSE biology is ‘easy’ and does not prepare pupils for further study. Interestingly these same contradictions, complexities and difficulties with concepts were identified by Bahar et al. (1999) in a study about the challenges of teaching genetics. The study suggested that many of the concepts in biology exist on three different thought levels (Bahar et al., 1999): the macro level which is tangible, the micro level which would include cellular and molecular concepts and the symbolic level which would include concepts such as patterns of inheritance and some biochemical pathways that are taught in a highly symbolic way. Pupils' perceptions of the more challenging content of the biology curriculum were also seen as a negatively contributing factor (Johnstone & Mahmoud, 1980). What is also interesting is that this links to a wider belief about how the subject is perceived by others and notably colleagues with other science specialisms and senior teams in school. It was clear from participants' comments that they had experienced some negative value judgements about the nature of biology as a subject and in their belief, given the challenging nature of the subject, this was unjustified.

All the participants in this study saw themselves as engaged in teaching a complex and challenging subject, something that, as explored in Chapter 1, has been recognised in the literature for a number of years (Reiss & Tunnicliffe, 2001). The secondary curriculum was felt to be extremely broad and included a wide range of biological facts and concepts that pupils needed to know, understand, and apply. The breadth of concepts that had to be taught in biology posed challenges, both for pupils and for the personal expertise of the teachers. Other challenges identified by participants included the complexity of technical vocabulary, the abstract nature of some of the concepts, mathematical content and the problems caused by how the curriculum was sequenced. However, participants did not always agree. Arron

commented that he felt that biology was ‘easy’ at GCSE and did not prepare pupils for higher level study and Emily saw biology as concrete and having a greater relevance to pupils’ lives when compared to the other sciences.

5.4.2 Others’ perceptions of the subject

When asked about the status of the subject, which had been commented on in the initial interview by one participant, Becky, there was a concern about the perception of the subject by others, particularly colleagues with a different science specialism. Becky’s initial comment below was made in relation to one of her photographs:

> *Yeah … because I get an awful lot, especially from physics teachers, in particular … oh, just get the colouring pencils out and I think there is kind of this idea that it’s all poster making and colouring in and … there is this, yeah there’s this stereotype of this is what biology is […] but I think that the difficulty erm … of biology is quite often kind of underplayed by other people, other scientists who do think of it as a bit of a soft option*
>
> (Becky, Interview 1)

When asked directly the other participants had similar stories to tell and Dan fiercely defended the status of the subject when asked about this, citing the complexities of the subject that he had previously identified:

> *I'd argue with them … vehemently … because actually if you look at the amount of stuff … I mean at KS3, for example, the KS3 scheme of work, there's one page of physics, one page of chemistry and 3 pages of biology … so actually the volume of things … and the words that we have to use … the precision of the words […] conceptually I think it's quite hard as well*

(Dan, Interview 2)

However, there was a counter argument from one participant who felt that, compared to the other sciences, biology had a relevance to everyday life in many of its topics that helped with pupil engagement, which in turn might contribute to it being seen as an easier option:

> *I … I always think that biology is seen as the easy option. That it's easy to understand and it is to a certain extent 'cos you've got … it is everything that you can see, isn't it? It's how you work and it's how nature works, and I think that is easier to understand than the concept of a star going into supernova at the other side of space […] which you can't picture in your head, and I know cells and things and we can go very small with … biology and … but it's still something that you can grasp*

(Emily, Interview 2)

The point was also made that biology may present options for more creative thinking in pupils that would also be a positive factor in engagement:

> *So, I think lots of people find biology much easier and it's also … it's less … it's more … I don't know what I'm trying to … how to put it …erm … chemistry and physics is a lot of right or wrong … whereas biology's a little bit more subjective … you can add your own spin on it a little bit …*

(Emily, Interview 2)

It was interesting that one participant viewed this potential for ambiguity as a positive thing as this is one of the points raised by Reiss and Tunnicliffe (2001) who argue that it is the very uncertain nature of biology that could give it a key role to play in

teaching students about the increasing awareness that claims for absolute scientific truth and objectivity may need to be questioned. The last set of GCSE and A-level reforms with their emphasis on the application of knowledge and awareness of experimental procedures and their limitations may herald the beginning of such a role for the subject.

Some participants also identified issues around how the pupils perceived the subject:

> *… yeah, and that's often the biggest complaint we get from A-level students and parents in the first six weeks … it's 'they're not doing any biology'. They've spent six weeks talking about the structure of biomolecules … that is biology … you know? But they don't see it that way, they see Biology as hearts, lungs, kidneys, livers, hormones*
>
> (Arron, Interview 2)

> *Erm … I do think, you know I do think even amongst the kids you do get quite a lot who go 'Oh I like Biology, Biology's easy'*
>
> (Becky, Interview 2)

Two of the participants felt that the school context and the wider culture also had a part to play in how the subject was perceived. The first remarked on science in general and the second argues that the perception of biology as the 'easy option' extends to school senior leaders when looking at a comparison of results at A-level how biology was viewed in comparison to the other two sciences. I have underlined some sections in Arron's excerpt for emphasis.

> *One of the things that seems to be quite … occurring quite often is … we're kind of like the forgotten core subject. This goes for the whole science*

teaching, not specifically biology … but we're kind of like the forgotten ones, the kids have to do science … they don't have an option but … they don't want to because it doesn't count as much as English and Maths and I feel that sometimes we're, kind of, pushed to one side

(Emily, Interview 2)

So, in that respect biology's held up to be … I think, the weaker of the three … or for the less … but it's not all … we're not treated with the same degree of patience … as, as err … as physicists and chemists are. I think if our results, our results at this school are not great for biology but for those reasons […] because it's tough err … and a lot of pressure has been put on us in the past, well it's only biology, I did it. Well … no, I don't think you quite get the err …

(Arron, Interview 2)

There is clearly a tension here between the participants' perceptions of their subject as complex and challenging and their perception of how other colleagues view biology. One of the recurring issues in the professional literature surrounding biology education is that of subject identity, and one of the key issues raised is the breadth of subjects that could be considered biology, something identified by participants in this study as a challenge both in terms of others' perceptions of what the subject involves and teacher expertise. In the literature there are often conflicting perspectives. Reiss (1998), for example, comments on the 'reasonableness' of widening the definition of biological science but also expresses a *concern* that in higher education a wide range of biology related subjects is included under the subject heading.

A comment from Arron appears to highlight both the issue of the broad range of degree specialisms that a biology teacher might enter the profession with and the ever-present issue of performance:

> *… because the […] EBacc* is all consuming … and I think you're also tied in with the special … the specialities of your teachers…*

*The English Baccalaureate: an accountability measure in England (DFE 2019)

(Arron, Interview 2)

It is also possible that the inherent characteristics of some aspects of biology knowledge cause it to be perceived as lower status than the physical sciences. It can deal with uncertainties; experimental work involving living organisms may not have the same precise repeatability of experimental work in the physical sciences at school; school biology lacks the mathematical content of physics and field work can involve many variables, which although they can be noted cannot always be controlled. A telling quote from Bronowski and Mazlish from 1960, cited in Mulhall and Gunstone (2012) reflects this idea:

> *... our confidence in any science is roughly proportional to the amount of mathematics it employs, and as we proceed to biology ... we know that we are fast slipping down a slope away from science.* (2012, p. 442)

Admittedly, this is an old reference, and one that it is easy to appropriate to make a point, but from my personal experience and that of my participants it would seem that the idea does still form a taken for granted part of the professional discourse in some areas of science education.

5.4.3 Tensions linked to teaching for understanding

Having identified some of the challenges of biology as a secondary school subject, participants also clearly expressed beliefs about how to approach biology teaching. A common theme was about teaching for understanding, which was one of the issues discussed in Chapter 1 and a cause for concern among biology education experts. In 2007, an editorial for the Journal of Biology Education, considered the 'great dilemma' in biology education, *'How do we deliver the crowded syllabus and desired exam results, while truly educating students?'* (Tunnicliffe & Ueckert, 2007, p. 51)

As explored in section 1.3 the authors, drawing on research by the National Association of Biology Teachers, a US body that has no equivalent in the UK, suggest that many students are learning phrases referred to as 'biology bytes' (p. 51) rather than developing a deep understanding of concepts and that teachers feel that the current assessment driven climate is making it impossible to teach the subject holistically. Some of these fears were certainly evident in the data from my interviews, some comments are underlined for emphasis:

> *… which I think sometimes with biology as well, that some of the Required Practicals, like food tests for example … that's a perfect example. That practical is just because they need to see what colour it changes to… <u>It's got no conceptual backing behind it</u>, it's just that changes colour, you need to know that that changes colour so […] because I think that we focus, we've focused a lot on content and getting the content done, teaching the specification and things like that … and I think doing what I've been doing with Mastery and the courses that I've been doing it's … I'm really starting to*

understand it. A student can work out an answer if they've got core principles that they understand

(Chris, Interview 2)

Chris revisited a similar idea in interview 3:

… what at the minute's probably influencing me is […] I've really started to understand that … that without those underlying stories and principles … if they're not in your brain … even if you don't remember it, you can still understand it

(Chris, Interview 3)

It was felt by all participants that an effective way to achieve this was through the use of modelling:

… erm, anything like that I love doing. Yeah! It's an awful lot of modelling …

(Becky, Interview 1)

Yeah … yeah, modelling and visualising. I very much try to teach enzymes in this way you know …

(Arron, Interview 1)

All of the participants also articulated the tensions between teaching for understanding and the pressures of exam performance:

I know what I was like as a sixteen-year-old and I know what I'd be like, will be like when my children are old enough. Those children … GCSEs will be the be all and end all and … they are for these kids, and they are for our school

because we're losing funding, we're losing … pupils so … we can't afford as an institution to, to just sort of say well, you know 'let's do a bit of exploring…'

(Arron, Interview 2)

So, I just thought I'd just take a picture of that and just say well that's what it boils down to at the end of the day, just an exam paper and that's what we're there to do, teach them the content and maybe, sometimes … that does take away from it a bit because you can't do everything you need to because you've got to make sure … that … you can't expand on stuff as much as, you can't then explore as much as want to because actually that's what we've got to get done, that's what we've got to, that's what we're restricted to

(Chris, Interview 1)

There was also a recognition that more creative ways of assessing pupils' understanding in lessons was beneficial and addressed inclusion issues but again cited the importance of examination success as a barrier:

… (image) ten is … a skeleton made out of buns which was something a Polish student in year 7 brought in for me a few years ago […] he was part of our science club […] and er he was really interested in muscles and movement and so one evening after science club I think it was I just sat down with him and talked through a few bones and a few muscles and he er the next week I think it was the week before Christmas he came in and he'd done this... and I just thought it summed up the imagination that the year 7s have […] Also that would be completely an anathema to many of the current, I don't know, awarding bodies. They wouldn't think to, to reward creativity in that way.

(Arron, Interview 1)

There were particular anxieties about the changes to the specifications and how these might affect decisions about pedagogy:

> *… and I think with the new spec it's far less easy to go off on a tangent … and kind of, explore […] with the, I mean, with the year elevens who've just left I felt very free to do what I wanted with them, but I think with the new spec …*

(Becky, Interview 2)

One participant pointed out that this perception that exam performance is the most important thing when teaching a subject also influences pupils' attitudes to that subject:

> *… and we're constrained by the fact that we have a generation of young, youngsters, but certainly in this school, who want to know the course and nothing but the course …*

(Arron, Interview 2)

A key and shared aspect of the participants' beliefs about teaching biology was the need to teach for understanding although there was recognition of the tensions between this aim and issues of content range, accountability for performance in assessments and time allocations in school.

5.4.4 The role of practical work

Opinions on the role of practical work were more divided and dissection was mentioned by everyone as a specific example of how biology practical work was unique. For many of the participants the use of dissection epitomised what they felt

was positive and interesting about biology practical work. A review of some current literature by Subramaniam (2014) around biology education reveals similar prevalent conceptions.

> *… so, I, that's why I picked it because when you say, 'what is biology?' the first thing they ask is what are you going to dissect?*
>
> (Dan, Interview 1)

> *Okay, so obviously the highlight. I get to do this with the triple classes. I don't do a dissection with anyone else at the moment but with the new scheme of work. So, I make it a bit special this time I got an ox heart*
>
> (Becky, Interview 1)

However, not all participants felt that way and one felt that sometimes even dissection could waste time or cause misconceptions among the pupils and that there were issues of personal expertise or the lack of it to be considered:

> *Yeah, yeah. So, I... so that is very much what I still like to do... to teach... and the one bit I suppose I'm really passionate about is the heart but funnily enough if you asked me to do a dissection of it, I'm utterly useless […] Because it's a lump of meat on a tray. I can't see the different structures*.
>
> (Arron, Interview 1)

Wider aspects of practical work brought several different perspectives, sometimes from the same person:

> *… erm … I would love it if we did as many practicals as we did with physics, like I would do a practical or some sort of demonstration every single physics lesson …*

(Chris, Interview 1)

But the unpredictable nature of some biology practicals, and the long-term nature of some experiments were seen as a challenge to the teacher:

> *Yeah. The only thing is sometimes practicals just don't work.*

(Chris, Interview 1)

There was an explicit acknowledgement of this conflict between what participants believed about teaching the subject when all factors were considered:

> *I sometimes worry that I'm just a walking contradiction at times […] you accept this is what I must do, and I need to do and then because we're intelligent people we … sort of … do I have to do it like that? … and you're kind of always between that conflict of this is what I want to do, and I need to do …*

(Arron, Interview 2)

Some participants saw the value in more investigative approaches having attempted these successfully in their classrooms:

> *It is a heart dissection. I think the kids need to get stuck in, need to see things for themselves. They need to be able to cut a heart up and find the bits inside of it themselves, without me having to say anything to them. Because I think if you just talk at them a lot … it doesn't go in … and they need to, they need to figure it out for themselves and I did, I did do a heart dissection this week with my biology, my GCSE biology group. I didn't give them any instructions I just said 'right, off you go' we had too many hearts for them so … erm so then they started asking me questions. Once they'd found the bits […] Asking*

questions, so once they'd found the heart strings … 'what's that?' … some of them noticed the difference in the thickness of the chambers …

(Emily, Interview 1)

There were also initial concerns about the recent reforms to practical work and the impact this might have on classroom practice:

… and you've got to do … whereas I've never seen practical … done practical … I've always used practical as a way to enthuse and … and work on it. But now it seems to be … this is going to be an exam ... you're going to be examined on this … so you need to listen, and you need to do it exactly this way, however I say do it, follow these instructions …

(Dan, Interview 2)

Practical work was seen as an important way of enhancing pupil understanding in the subject for most of the participants although one person felt conflicted and echoed the concerns of notable experts in the field about the conceptual benefit of some practical activities (Abrahams & Millar, 2008, Philip & Taber, 2016). A number of participants also recognised the potential benefit of inquiry approaches in practical activities but again it was recognised that time constraints and the pressure to 'cover the content' presented potential barriers to this approach.

5.4.5 Relating the subject to pupils' lives

A final factor deemed important in the approach to teaching biology was the importance of relating the work to pupils' lives and how this can present challenges:

Right, we've done this, we've also got to talk about how plants reproduce now, and you can just see their faces drop and just like … 'oh, why do I care?

I don't care' and tropisms […] is just the one thing that you have to go over and over and over again and it's because the kids don't, they don't really care.

(Becky, Interview 1)

Just making it actually … it is actually real, it's not like it's just something we talk about and sometimes you find that we talk about evolution and you, like get to the end of a lesson and they've all learnt it, they can tell you what the process of evolution is, then you'll always get someone who's just like, but that isn't real is it though? Yes!!! Yes, it is real, it's tough to actually convert what they've learned into the fact that this is real life.

(Chris, Interview 1)

One participant felt that an important aspect of this was to involve pupils in genuine scientific projects. In the following excerpt he refers to a collaborative investigation project that some classes had been involved in:

It's relevant to what's, what's happening in the day-to-day world … Tim Peake was one of the biggest stories of the year probably … and again, it went back to that engagement of students … who instantly saw that and forgot it was a boring subject, biology, it was something fun.

(Dan, Interview 1)

In summary, most participants felt that, as a science subject, biology had the advantage of being directly relevant to pupils' lives, at an early stage through an interest in the human body and how it works but also in terms of current environmental concerns. However, participants felt that the subject as taught did not always capitalise on this relevance. McComas et al. (2018) highlight the importance

of biology education in the twenty first century calling this ‘an exceptional age’ from a biological perspective, citing the current concerns about extinction, climate change and the evolving threat from disease as key concerns in the world. Interestingly in section 5.6 Chris expresses his frustration that the secondary school programme of study appears not to include some of these key issues and contemporary biology developments.

5.4.6 Summary: Expressed beliefs about teaching biology

Participants' expressed beliefs about teaching biology suggested that they felt that they were dealing with a complex and challenging subject that is often underestimated by pupils, other science specialists and senior teams within schools. All participants noted the importance of teaching for understanding but many of them expressed concerns about the perceived tensions between the range of content in the secondary curriculum, the pressures of obtaining examination success for pupils and time constraints and pedagogical approaches that they considered to be effective for conceptual development and engagement.

5.5 Teachers’ perceptions of the way in which previous experiences with their subject have influenced their beliefs

Having explored some of the relevant literature I had been expecting early, less formal, experiences with the subject to influence the participants' ideas about *how* the subject should be taught. In this section I consider how the participants in my study perceived that early informal subject experiences were influencing their biology teaching. The data from the interviews suggested that such experiences were more significant in terms of their ideas about the role and purpose of secondary biology. Where they did make links between early experiences and classroom decisions

these were always related to their more formal personal experiences with the subject as pupils or students. This contrasts with findings from a number of studies that have suggested that early informal experiences with the subject influence pedagogical decisions in science teachers, see Section 5.3 (Smith, 2005, Estola et al., 2003, Halai, 2011). My participants' early informal experiences with the subject varied from an interest in natural history or human biology to a more general interest in science through exposure from parents. Their stories about this can be found earlier in this chapter in Section 5.3.1. These experiences clearly seemed to spark an interest in biology and appeared to be influencing the choice of the subject at A-level and beyond. These experiences seemed to be significant to their beliefs about the role of biology as a subject at secondary school and, although this in turn may influence how the subject is approached in the classroom, no-one expressed any direct links to how they felt the subject should be taught. Arron's experiences, for example, were around human biology and health:

> *I just see there's so many strong links between biology and PSHE … There's, there's the obvious ones but then there are a lot of … so many similarities in areas that you wouldn't think about. Public health, erm … and all these ideas of British values. An awful lot of British values are tied in with how we live healthy lives.*
>
> (Arron, Interview 2)

Emily meanwhile remembered experiences of the natural world, a love of animals and visits to 'wild' places:

> *Right, well they all kind of link into the same, the same idea … I think that teaching biology is just about teaching the life around the kids […] Yeah, and*

the fact that the forests are being cut down and why that's important and all those sorts of things …

(Emily, Interview 1)

Interestingly, Arron expressed a feeling that he had been manoeuvred into taking biology and later sciences in general and it would appear that as a consequence he had an understanding of the subject more as a strategic step in pupils' education and saw the role of the subject as more about improving the life chances of pupils in general. Again, this provided additional evidence that early experiences are contributing to beliefs about the perceived purpose of the subject:

I did well in all my GCSEs, but I think if I'm really honest with myself I wanted to do humanities, but I allowed myself to be talked out of it by various people

(Arron, Interview 2)

Thinking about the attitudes of the pupils that he is teaching, for example, he stated:

Yeah, I don't think that they're appreciating it for what it is, because very few of them want to do Biology, in terms of 'I want to be a Biologist' […] they want to do Biology as a gateway to medicine, to dentistry … or because it's an A-level that's recognised by traditional universities

(Arron, Interview 2)

This excerpt suggests how this might be having an impact on his values around his role as a teacher:

I don't know now, I'm not quite … want to say 'class warrior' but I don't know if I actually want … if I'm sticking with it just because I want to help these kids do something with their lives … I think … I sometimes think if we haven't …

actually took some of the emotion out of being a … a teacher and … weren't quite so passionate about our subjects […] and actually appreciated that really for a great many of our kids we're a cog in the wheel […] I think that's probably now, my main motivation for continuing to be a teacher of any sort is that there's still a … you know … we morally owe some of our young people an opportunity to […] and they must be given every chance to progress …

(Arron, Interview 2)

One factor that did seem to be significant to how the participants felt the subject should be taught was their own formal experiences of biology and sometimes science more generally:

I think that's quite important because I, when I was at school, we did quite a lot of practicals and things like that and that's why I wanted to teach biology

(Chris Interview 1)

… yeah. Why don't you go outside? and why don't you do this …? or why don't you actually put that into practice and go and … go to that tree and measure some stuff? … Or why are you just telling them that … the abiotic factors of an ecosystem, why don't you go out and … measure some!? […] why don't you do something and link it to … biology?

(Dan, Interview 2)

Several studies have focused on the link between beliefs and personal experiences with formal education (Pajares, 1992, Smith, 2005, Halai, 2011). As early as 1975 Lortie referred to 'the apprenticeship of observation' that beginning teachers already have from their own educational experiences (Snider & Roehl, 2007) and there is a

tacit understanding in teacher education programmes that beginning teachers will default to teaching pupils in the way that they were taught, particularly when feeling under pressure. The relevant literature, however, suggests that there is a lack of empirical evidence to support this assumption (Oleson & Hora, 2013, Cox, 2014) noting that although teachers may mimic aspects of their own instruction, they also draw on their own continually developing knowledge, which is being influenced by a number of interacting factors (Oleson & Hora, 2013). Certainly, the evidence in this study suggests that this is the case. In terms of formal experiences with the subject, personal experiences of practical work were recounted by all participants. Personal enjoyment of and engagement with practical work were cited as the influences for valuing practical lessons as a pedagogical approach in biology by most participants or, where there was doubt about its value as a pedagogical approach, this was also related to previous experiences in formal education.

Chris remembered very little about any early, informal interest in biology, but cited his experiences while at his own secondary school as highly formative. In Chris' case the memory of being in science lessons at the school was so positive (see section 5.3.2) that his aim had always been to secure employment as a teacher there; something that he achieved part way through the study. However, as suggested by Oleson and Hora, the stories that my participants told do suggest something more complex than emulating their own experiences as a pupil.

My final research question was ‘What are biology teachers' perceptions of how they can implement their beliefs in the classroom?’ and an analysis of the data suggested two themes linked to this.

5.6 Teachers' perceptions of their pedagogical agency

My analysis of the data suggested that all the participants were telling stories about their perception of their own pedagogical agency, that is, their perceived ability to make choices about teaching and learning approaches within the school context. It is worth reiterating that when selecting participants for this study I deliberately chose to work with teachers who were not working in contexts that prescribed specific pedagogic approaches for all staff for each lesson to ensure that I was talking to participants who had as much freedom over their classroom decisions as possible. Agency has been defined as 'the socio-culturally mediated capacity to act' (Ahearn, 2001 cited in Buchanan, 2015) and 'the capacity to act according to professional values, beliefs, goals and knowledge' (Toom et al., 2015, p. 616). Studies of teacher agency have suggested that teachers with agency perceive themselves as pedagogical experts and feel able to act in creative ways in the classroom (Toom et al., 2015). This was not something specifically asked about in the interviews but emerged as a theme as I analysed the data.

In several cases participants talked about pedagogical approaches that they had taken and commented that there were no constraints on them approaching their lessons in this way. They felt that they had some agency over the decisions about how to teach their lessons. When asked about being able to do dissection practicals with his pupils, as this had been identified as a casualty of time constraints by other participants, Dan noted:

> *Yeah, we haven't been limited in any way …*
>
> (Dan, Interview 1)

And again:

The school are very good because they, kind of, let me do what I want. So, I've never had any … I've never had any barriers to what I want to teach.

(Dan, Interview 2)

Dan felt that having what he perceived as the freedom to develop more creative approaches to his teaching directly enhanced understanding. In the following excerpt he describes an unplanned impact on pupils' understanding from a national project that he became involved with:

… going back to that Tim Peake seed thing […] with a group we did a mock test and there was a question that was quite difficult […] and the answer was erm … 'it's so we can compare' … and share with other scientists and […] that was a six mark question and most of the kids got that and I was concerned […] because we haven't actually sat and said in any other lessons 'Oh well, scientists share ideas so they can compare' […] but that process of growing the seeds and doing … explaining why they do what they do … they all answered that question really well …

(Dan, Interview 1)

In a similar vein, several participants talked about how they had adopted more inquiry-based approaches in their lessons. For example, from the previous section a reminder about Emily's approach to heart dissection:

I did do a heart dissection this week with my biology, my GCSE biology group. I didn't give them any instructions I just said 'right, off you go' …

(Emily, Interview 1)

Inquiry based approaches in science are based on constructivist learning theory (Eick & Reed, 2002). Such approaches are seen as an important factor in pupil engagement and there is evidence to support that they contribute to conceptual understanding as suggested by Dan in the previous excerpt (Stroupe, 2014, Capps & Crawford, 2017). Others have found that a commitment to use inquiry approaches in the classroom was not just linked to teachers' beliefs about teaching their subject but it also contributed to their beliefs in their self-efficacy, their ability to have a positive effect on the learning of their pupils (Leonard et al., 2010) This is perhaps because planning lessons that focus on aspects of inquiry require teachers to reflect on their pedagogy and be innovative in their responses to pupils' needs (Stroupe, 2014).

Using aspects of inquiry approaches in their lessons appeared contributing to the teachers' feelings of agency, their ability to act in accordance with their beliefs about teaching biology. However, in some cases time constraints, curriculum reform and the pressure to ensure exam success were felt to be limiting their choice to approach lessons in this way:

> *I don't think I try to do it all but I'd like to, but I don't think I try because I think you … we're constrained by the course … and we're constrained by the fact that we have a generation of young, youngsters, but certainly in this school, who want to know the course and nothing but the course …*[…] *we can't afford as an institution to, to just sort of say well, you know 'let's do a bit of exploring' […] because the stakes are so high.*
>
> (Arron, Interview 2)

The GCSE reforms, which were being introduced at the time of the second round of interviews for most participants, were a seen as a potential barrier to inquiry approaches. Becky shares her concerns below:

> *… and just realising how much content there is … to get through and I think with the new spec it's far less easy to go off on a tangent and, kind of, explore that stuff … with the […] with the year elevens who've just left I felt very free to do what I wanted with them but I think with the new spec, either it's a case of … they're not entirely sure what's going to be examined or, or what the kind of, the exam's going to look like.*
>
> (Becky, Interview 2)

Later in the same interview after being asked about the introduction of the Required Practical component of the reformed GCSEs:

> *[…] I think it's made the practicals far less enjoyable and […] I don't think the kids are enjoying the practicals as much now either it's not the case that you can say right, we'll do this and then we'll have … you know, a big discussion and I'll just see what you find, because it's being documented and because they've got to show that they've got all of these various skills so that then all of the practicals are very regimented […] you don't really have that freedom of actual experimentation, of trying to find stuff out.*
>
> (Becky, Interview 2)

Dan had similar anxieties about the effect that the Required Practicals might have on his teaching:

… and there's not enough time to do … even the required practicals, I think, it's just taken all the fun out of … doing a practical just for the sake of doing it … it's, kind of, it's too prescriptive and it doesn't allow teacher creativity to do what they want.

(Dan, Interview 2)

Two things appeared to be significant in looking at this data. The first was that some of the comments about lack of agency over classroom decisions seemed to reflect personal assumptions rather than actual constraints imposed by the school context. There were several comments about what others would perceive as 'good teaching.'

So, (image) nine was again, another example of, I suppose Assessment for Learning […] so you've got some instant ... peer assessment there ... so this was a year 12 lesson […] I wrote a comprehension question out, they marked it ... I displayed the answer and then displayed it against a model answer […] So it had all the, the sort of feed forward, feed-back … <u>everything with bells on really that it needed to do.</u>

(Arron, Interview 1)

In a similar way Emily explains her assumption that effective lessons had to involve PowerPoint slides and the positive impact of suddenly not being able to deliver a lesson in that way:

We got one of those viruses … we had no computers at all … I had to rearrange my seating plans because I had most of the kids over there to see the whiteboard, but I moved over to this board and my style of teaching changed […] but I think the kids listened to me more […] I remember teaching

ionic bonding and drawing out diagrams and it was 'chalk and talk' … because it wasn't just a picture that then went off …

P: You were building it up?

E: Yeah […] and there was a difference to how the kids perceived it and how I enjoyed teaching it.

(Emily, Interview 2)

The second thing that seemed to be significant for four of the participants was some degree of explicit acknowledgement of expertise, even if not directly connected to classroom teaching. This seemed to act as 'permission' to try things out and contributed to feelings of agency in the school.

I'm know as a bit of … the trip guy … the one who does all the trips […] to get students out of the classroom […] this is the way I try and, again, back to engagement of students, get them to see biology in a different picture than just, there's me talking at a whiteboard.

(Dan, Interview 1)

Formal recognition of a role in innovating lesson approaches within a department was also powerful:

… there's like a team of 4 of us trying to plan this, we're not going to do this next year, we're going to do it, hopefully the year after, although actually our curriculum is 5 years. There's not a KS3 curriculum, there's not a KS4 curriculum […] how are we going to put the building blocks in so that they understand it.

(Chris, Interview 2)

Indeed, Chris presented an interesting perspective on the perception of pedagogical agency in that he changed school context part of the way through the study in order to teach in a school that he felt actively encouraged teachers to be creative and innovative and supported professional development financially. He gave an insight into the role that the culture of the school can play in teachers' perceptions of their agency within the classroom, particularly when compared to comments about exam performance pressures from Arron. In the next excerpt Chris talks about his new school context when prompted to reflect on the impact it might be having. This is quite a long excerpt and includes one of my responses because to me it felt like a key moment in our discussion about classroom decisions:

> *P: You're in a quite unique position in that you've just changed school context […] have you got any feelings about what effect the school context has on your … teaching decisions?*
>
> *C: Oh, massively. We have, at this school, because we're in such a … we are the lead school of an academy trust … and we just … the opportunities to try new things. Just do something different is […] the opportunity to experiment has affected my … and like I said about the practicals, doing a practical first … what practicals work? […] It's like, just … we have a lot more facilities and it's that opportunity to do something different as well, that we've got in here as […] well we know we've got time in year eleven … stretch that topic out, explore it a little more which I have enjoyed a lot […] which means we know we can push, and we can change, and we can do extra things which I think is really good … and just […]*

P: I mean just looking at your body language … and your tone of voice, you're obviously absolutely loving … that, that kind of freedom …

(Chris, Interview 2)

Some participants identified barriers to complete freedom of pedagogical approach that were related to the programme of study in biology. An issue that Chris spoke about at length was that the biology curriculum did not reflect contemporary issues sufficiently and lacked some of the current challenges and developments in the subject. He felt that this prevented him from teaching about concepts that he was interested in and felt to be very important:

I would personally rather be talking about stuff that happened last week about … like antibiotic resistance and how bad it is and stuff like that and I'd like to be doing practicals that relate to new stuff. The specification hasn't really changed that much but in terms of … I'd rather relate it to new stuff, and I don't […] some of the topics that we do seem very backwards to me, like I think there's so many opportunities, like I love new biology […] and we're still teaching this old stuff […] Let's talk about the modern issues … about, actually, that biology is going to change a lot in the next few years, and actually can we make it more relatable to the students?

(Chris, Interview 2)

An interesting concern that brought together issues about the content of the curriculum and anxieties about external influences on teachers came from Arron who was concerned about potential societal influences on biology teaching:

It feels in my time as a teacher that we've … especially in a catholic school, contraception was a bit of a big no-no … Now it's become that you can … it's

accepted, perfectly fine part of the course to teach … But then vaccination seems to be now this thing that we're […] A bit more careful about …

(Arron, Interview 3)

In this study the participants mostly expressed feelings of pedagogical agency and appeared to feel supported by the school context as none of their schools at the time of the study had imposed any specific pedagogical approaches on their staff. However, there appeared to be some self-imposed pedagogical restrictions. Participants expressed ideas about what might be considered 'good' teaching or restrictions that could be imposed, using terms that suggest they perceived a degree of management panopticism (Ball, 2003).

There were also perceived constraints in view of the GCSE reformed specifications which was understandable, but again, Becky refers to a perceived 'them' when describing her reluctance to be pedagogically innovative in this context:

I think with the new spec it's far less easy to go off on a tangent … and, kind of, explore […] I think with the new spec […] they're not entirely sure what's going to be examined or, or what the kind of, the exam's going to look like

(Becky, Interview 2)

The accountability / performativity discourse in schools, defined by Ball (2003) as a culture that employs judgement comparisons as a means of incentive and control, was never far from the participants' thoughts when they discussed their ability to implement their beliefs about teaching biology, with the tensions often clearly being thought through as they told their stories. At least one participant had begun to question some of his own existing assumptions about what might be 'allowed' in terms of pedagogy as he recalls empathising with a retiring colleague:

… he just didn't like the pressure […] and he retired and on his last day speech he was quite tearful and emotional, and he said 'it's not all about results. It's not all about the exams, it's not grades, it's not about that. Don't think that that's what you're here for […] because that will happen, the grades will come themselves […] but don't […] walk in this door thinking that it's about what grade this kid's going to get.

(Chris, Interview 3)

This stance of questioning appears to be further developed in Chris as he works with an external expert on pedagogical approaches for Mastery in science, something that I will discuss in the next section.

In light of retention concerns in the teaching profession there is a growing body of research that examines the factors that contribute to teacher well-being (Niemiec & Ryan, 2009, Hobson & Maxwell, 2017) and among these it is noted that the extent to which teachers perceive that they have autonomy over their work is noted as a key factor. Self Determination Theory, a theory of human motivation, emotion and development is increasingly being applied to educational settings as a way of exploring these issues of well-being and retention (Niemiec & Ryan, 2009). Such research suggests that motivation is enhanced by meeting the three needs of competence, relatedness and autonomy and my data from this study appear to support the importance of teachers' feelings of autonomy to their satisfaction with their school context. Participants feelings of pedagogical agency seemed to be enhanced when some element of 'permission' to be innovative was given, whether through official recognition of expertise and a responsibility for developing departmental pedagogy or a more informal recognition of that aspect of their

teaching by peers. Where they felt frustrated by a lack of agency the participants cited issues with biology as a subject in secondary school such as the actual content and the time available to teach concepts, echoing some of the issues raised at the beginning of this chapter. All participants noted feelings pressure to ensure exam success as a constant consideration and again, felt that this impacted on their freedom to teach in the ways that they wanted but in most cases this was related to a *perceived* lack of autonomy rather than any specific constraints imposed by the schools that they taught in.

5.7 Relationality and the development of professional subject Knowledge

In this section I look at examples from the data that describe how relationships with others appear to be influencing pedagogical decisions and approaches to biology teaching. One aspect of this was the influence that ongoing interaction with their own pupils was having on the teachers' classroom approaches:

Here are some excerpts of participants talking about the pupils that they are teaching:

> *… which is when I've just done Ecology with my kids, year 13s, all of a sudden year 13s have said 'we've not done the Ecology practical' … panic … well … we couldn't do it last week we were knee deep in mud on the field. When, when can we do this? We're going to have to go out after Easter and I'll show you how to do it*
>
> (Arron, Interview 2)

> *So, I'd got a random kid who'd brought me a, like, a bird skeleton once … Like in just a jar, and I'd found this in the garden, and it was totally grossed out because it was half decomposed and half still got, like, soft tissue attached …*

didn't smell very good, and again using that … so that's how I use my teaching … try and identify kids who've got an interest.

(Dan, Interview 2)

… how, 'cos <u>our kids</u> in particular, I'm assuming that it's quite a broad thing, but they struggle with the practical skills when …

(Emily, Interview 3)

One thing to note in these excerpts is the language: 'my kids,' 'our kids' which to me suggested a very positive relationship with the pupils being taught. Some of these comments suggested more than just an understanding of a pupil's particular learning needs or a knowledge of which aspects of biology they would find challenging. I interpreted these comments as evidence of an evolving understanding of the subject as seen through the pupils' eyes and, by my interpretation, stories of 'being in it together' to understand biological concepts.

Here is Dan again, talking about his role in organising and running trips at the school:

Yeah, that's year 10s and 11s, forty odd. No, it were a really good day. Again, they were mesmerised by everything that they saw … they kept coming back and showing me pictures, and I'm like, 'Yeah, I know I've seen it.'

(Dan, Interview 1)

There was a great deal of affection evident as he talked about this. He described himself doing something quite challenging, out of the controlled classroom environment, with a large group of pupils. As he recalled the incident, I got a sense of the relationship between him and the pupils that he was working with. Dan

describes the importance of giving pupils a wider cultural experience in the knowledge that they probably would not have had an opportunity for this normally:

> *… It's more than that it's getting them out of the classroom and seeing things that … very few of them in this picture would have ever seen before. If it weren't me taking them, they would have never seen that … great big, dinosaur fossil. They wouldn't have been able to do it because their parents wouldn't take them […] so we had to take them to London just to see the buildings … and the traffic … and landmarks were an experience in itself.*
>
> (Dan, Interview 1)

He also describes the enthusiasm of the pupils as they come back and share their experiences with him.

> *… they kept coming back and showing me pictures, and I'm like, 'Yeah, I know I've seen it' (laughs). 'I've seen this many times.' 'It's great! So, have you seen it?' 'Yeah, yeah I have seen it, I have been here before'. Erm … again, our kids when they go out of M********* …*
>
> (Dan, Interview 1)

For one participant there appeared to be an interesting link between relationships with pupils and perception of pedagogical agency. At his initial school he empathised with the lack of practical opportunities for some pupils who are not 'allowed' to do dissection due to time constraints in the department's scheme of work for some GCSE groups:

> *They've seen, they've heard that in that year people are cutting up hearts but they're in 'Core' and 'Additional'… they get really down, some of the kids*

(Chris, Interview 1)

As described earlier, Chris changed schools during the study, moving from his first post to teach at the same school that he had been a pupil at, something that had been his goal since qualifying as a teacher. By the third interview Chris was well-established in his second school and told me about working with a challenging pupil in the way that he had always wanted to, using the additional 'investigative' curriculum time available to him:

> *… they get to the equation themselves, like the 'moments' one they did the other day. I had 10B5 so I said right it's force, because they'd worked out that it was force, weight - because we'd done that before and there was distance and I said so how much is this? and they got there and they were like, do you add them together? and I was … no … do we add them? What do we do? Then they got there themselves and it's like when they see that equation it's oh yeah, it makes sense […] J**** was like, it's just that … he's a nutter (smiling) … but when he … like the week he walked in and all the weights were there … he was throwing the weights around like that and obviously I was like, calm down, calm down … but … he got there himself, without anyone helping him. He likes to work on his own, no one helping him and then he was like, I caught him out of the corner of my eye, and he was like …(whispers) 'I put four here and eight here …'*

(Chris, Interview 3)

There appeared to be a great deal of positive emotion evident in the telling of this story and a pride, not in the pedagogical approach but linked to the pupil himself

which came across to me through the way he described the pupil's transformation in the lesson.

There is also an affection for and a clear wish to improve the lives of pupils, and my interviews suggested that this affection develops as the relationships build. It seemed to be an evolving part of the teachers' set of beliefs about teaching biology, something beautifully articulated by Dan as he told me about his journey to becoming a biology teacher:

> *… so, I kind of thought what better job than to talk about science or biology all day than a teacher, so that's what it … that's my main motivation for becoming a teacher, just to be able to be in a job where, not necessarily working… I'd no interest in being a scientist … or in field work or anything […] but then when I got into teaching it actually … the kids took over and it kind of became a joint thing … it weren't just about, I liked biology and there's kids there … It became I liked biology and I really liked the kids.*
>
> (Dan, Interview 2)

As they told their stories it appeared that this powerful empathy with the pupils in their schools was encouraging participants to reflect on their own experiences as pupils and again, there were clear links to some of the beliefs that they had expressed earlier, for example, about the complexities of the subject and the difficult transition to A-level:

> *… and also, I found it hard because I cruised through GCSE Biology … and suddenly found this extra, extra stuff on a subject I thought I was pretty good at.*
>
> (Arron, Interview 2)

Sometimes the participants expressed conflict between wanting to teach in a way that they had enjoyed as pupils and the, sometimes challenging, nature of biology practicals from the teacher's perspective as in the excerpt below:

> *I think that's quite important because I, when I was at school, we did quite a lot of practicals and things like that and that's why I wanted to teach biology erm … but I think that most of the time that's not how biology gets taught.*
>
> (Chris, Interview 1)

The participants also reflected on particular aspects of the subject that pupils appear to enjoy that they had also enjoyed: here Dan talks about his interest in human biology:

> *… I think a lot of students when they're studying biology, they want to know about the body … and just I had the same thing.*
>
> (Dan, Interview 2)

Four of the participants reflected on their experiences with teachers as pupils themselves and the felt that these positive experiences had inspired their classroom approaches and the kind of teachers that they felt that they wanted to be:

> *Teachers … I think I had some really good teachers … who, who clearly loved science and, and they kind of helped me.*
>
> (Dan, Interview 2)

> *I think I still want to be that biology teacher that, at least, even if it's just one, she did, you know she did some really good lessons and as a result I want to be in the science field […] because I remember that it, for me it was my*

physics teacher, so he's probably annoyed that I did biology (both laugh) but it … that I think that's quite powerful, the fact that you can influence …

(Emily, Interview 3)

Yeah, so that's how I recognise, because I thought, I kind of think that I was like that kid and teachers did that to me […] and then hopefully that has a knock-on effect with other kids who're maybe not so interested in science … or biology they can then … they can then, kind of, become a bit enthused about it.

(Dan, Interview 2)

As I was listening to these stories about pupils, particularly with Dan, I realised that the participants were making a connection between the subject, their own experiences as pupils and a growing understanding of the pupils that they were working with and some of them were expressing the idea of 'teaching the younger me':

… in fact, I recently had a kid, he's extremely bright, he's got extremely pushy parents, he plays, like, three instruments and they want the best for him but they're very … they're very pushy and erm … we were chatting at parents' evening, and I think he finds me quite intimidating … I don't know why but he does really find me quite intimidating and actually he's the kid that's most like me.

(Dan, Interview 2)

My analysis of the interview data suggests therefore that a key factor contributing to teachers' expressed beliefs about the subject is a developing understanding of the

pupils that they are working with, not just in the technical sense of understanding pupil behaviour management and theories of learning but an emotional connection leading to an empathy that also appears to prompt reflection back to their own experiences as pupils. Empathy is a theoretical construct from social psychology that has both an intellectual and emotional aspect (Warren, 2013). In this context the intellectual or 'perspective taking aspect' of empathy (Warren, 2013) is the ability to see subject issues from the pupils' perspective, for example Becky discussing the challenges of specialist vocabulary:

> *…a real, real problem is them being able to learn this huge array of vocabulary and be able to use it the way that the examiners expect them to be able to use it […] homozygous, heterozygous and all of those … and it's just that the words are so similar …*
>
> (Becky, Interview 1)

The emotional aspect of empathy in this context is the element of empathic concern for pupils. In the following extract, Dan speaks of talking to a pupil who is finding being in his class a challenge:

> *I don't know why but he does really find me quite intimidating and actually he's the kid that's most like me … when I was a kid, so I'm like, J******* why are you so intimidated by me? You're literally me when I was your age […] I was the one that's sat at the front, listening, who asks extra questions like you do … you really shouldn't be intimidated.*
>
> (Dan, Interview 2)

In this excerpt empathic concern is further emphasised by a recognition of similarities with the participant's younger self. I found examples of this in a number of

interviews. Franzese (2017) actually uses the term 'recognition' in the context of empathy and defines empathy in the context of teaching as not just recognising the content that you are teaching and its potential conceptual challenges but recognising the pupils that you are teaching. In other literature this is described as 'student (pupil) level understanding' (Barr, 2011, Warren, 2013). In the case of some of my participants this seemed to be working at another level as well, that of recognising themselves in their pupils.

The research literature on empathy in classrooms appears to mainly focus on culturally diverse contexts and argues for a need to place pupils' social and cultural needs at the centre of pedagogical decisions (Warren, 2013, Meyers et al., 2019). An interesting point to note is that all my participants were or are working in school contexts that could be considered to be in socio-economically deprived areas and most of them also had a personal history in those areas or areas that were very similar. In this study the teachers told stories of working to understand the pupils' conceptual difficulties with biology as a subject but also of their growing understanding of the wider challenges that pupils face, such as their own struggles with the accountability culture in schools and their perception that they have potentially limited opportunities such as Dan’s story of the trip with KS4 pupils to the Natural History Museum in London.

In distilling the data, I was aware that I found the comments about relationships with pupils and the obvious empathy being displayed had particular resonance for me as the researcher and were the first aspects of the relational theme that I noted. However, on continuing to work with the data it was clear that other relationships were also influencing classroom decisions.

Another relational aspect that my analysis suggested might be impacting on teachers' beliefs and, by extension, their pedagogical decisions were their interactions with knowledgeable others. In some cases, this was an interaction with a wider community of subject specialists through, in one case, membership of the editorial board of a school science magazine or through social media sites.

> *So (image) seven is 'Big Picture' now, I'm actually on the teaching advisory board for Big Picture (Science Magazine aimed at secondary pupils) […] biology teaching... and being nosy and never saying no to anybody has really got me into sort of being on this board and opened up other avenues and, you know, it's a fantastic sort of opportunity to work and see other people and just find out so, so much stuff, that you know, I learn something every time I go to one of these meetings because I'm surrounded by people who have been teaching for thirty or forty years in different schools …*
>
> (Arron, Interview 1)

Dan does this peer collaboration and sharing of good practice in a virtual way:

> *I'm quite big on Twitter so I always use Twitter to follow the new techniques and I think teachers are sharing ideas more about teaching and learning […] if I go on social media and interact with other teachers there's more sharing across the country […] it's like, essentially, it's like a huge Teach Meet …*
>
> (Dan, Interview 3)

Relationships with colleagues in the school were also seen as important, particularly experienced subject specialists who shared ideas and acted as informal mentors. Here Becky discusses the pedagogical support that she feels she has received in the department:

*H**** who is the former head of department was a fantastic biology teacher […] we've been doing quite a lot of sharing ideas.*

(Becky, Interview 3)

In a similar way Dan remembered influential colleagues who contributed to his developing pedagogical while on placement in his PGCE year:

… training I saw some great biology teachers as well […] Who would defend biology but who would be great and, kind of, share their ideas

(Dan, Interview 2)

All of the teachers told stories about working with others as a way of continuing to develop their knowledge and classroom practice. For some, like Arron and Dan this was an interaction with an online community of science teachers and colleagues from different settings as they worked on different projects or shared ideas. For others it was informal working with colleagues in the department to share ideas about approaches to teaching. For all the participants, working with others appeared to have a positive impact on their perceptions of their ability to act on their beliefs in the classroom. For Chris, however, 'working with others' took the form of formal, at-elbow Continuing Professional Development (CPD) and appeared to be extremely powerful for him. Chris told a story of working with a Mastery Science consultant. Mastery Science is a pedagogical approach to teaching science that uses the idea that teaching pupils to understand key principles in science education (Harlen, 2010) and giving them the time to consolidate this understanding through application. Although this was an example of consultant support bought in by the school, the support that Chris described resonated with a similar experience in my early years of teaching. Chris describes both working with the consultant in a group of staff to

examine ideas about knowledge and misconceptions and working alongside the expert with his own classes to look at pedagogical approaches. Chris explained how he had gained formal knowledge from his PGCE year but had not really understood the application of that knowledge until he had this opportunity to work alongside someone else:

> *I think … I … I think it was the fact that I didn't really understand … without seeing kids applying misconceptions … I didn't understand … how important that was … when you're teaching you obviously get chance to … but … oh, I don't know how to explain it … I think that one of the things that T*** showed us, T*** made it clear to us how concepts work …*
>
> (Chris, Interview 3)

Although Chris was the only participant with this experience it appeared to be a powerful one for him. What was particularly interesting for me was the fact that several of the issues that he discussed, for example how using Bloom's Taxonomy to plan lessons might lead to an over-emphasis on recall at the expense of conceptual understanding (see the excerpt below), are part of the work that we do with pre-service teachers.

> *I think as well, sometimes that's where Bloom's … now I'm a bit … oh, I don't like it as much because we … that's how we set out our learning now […] what's the first thing on Bloom's? It's, be able to state something … and I …I remember teaching in that order … and it shouldn't be like that*
>
> *P: Whereas you should be aiming for understanding and then that's the bit you do …*
>
> *C: do afterwards, yeah*

(Chris, Interview 3)

This made me reflect on the concept of teacher knowledge that I discussed in Chapter 2 and consider that beginning teachers may not be ready to engage with the underpinning theory of classroom approaches, the ‘formal’ knowledge that we deliver in the PGCE year, and that it may therefore be important to revisit some of these ideas with early career teachers as their personal practical knowledge develops. This is an area that I explore in further detail in Chapter 6.

5.8 Summary: implementing beliefs about teaching biology

My third research question focused on biology teachers' perceptions of how they can implement their beliefs in the classroom. Upon analysing the data two themes related to this question emerged for me. The first related to the participants’ perceptions of their pedagogical agency and the factors that they felt were influencing this. The second, related, area concerned the influence that different relationships (with pupils and with colleagues and others) were having on both their perception of their agency and on their classroom decisions. In the next chapter I explore these themes further, using relevant literature to make links between relationships, teacher knowledge and agency. Key for all participants was an evolving understanding of and empathy with the pupils that they were teaching and from this a reflection upon their own experiences as pupils, but relationships with subject colleagues, wider subject specialist groups and in one case a pedagogy expert were all mentioned as influences on their classroom decisions.

5.9 Chapter summary

In this chapter I have presented my findings from my data analysis. The chapter began with the narratives that I constructed from my interview data to try to tell my

participants' stories of becoming a biology teacher and their early experiences with their subject in their own words. Four key areas of interest, related to my initial research questions, were identified through my analysis of the data and these were presented with excerpts from the interview data. These were

- teachers' expressed beliefs about teaching biology
- teachers' perceptions of the way in which previous experiences with their subject have influenced their beliefs about teaching biology

Themes that related to my third research question were:

- teachers' perceptions of their pedagogical agency
- relationality and the development of professional subject knowledge.

Chapter 6: Discussion

6.1 Introduction

I began my study by asking questions about how personal subject experiences influence biology teachers' pedagogical thinking. I was interested in teachers' perceptions of how previous experiences with their subject had or were influencing their beliefs about teaching biology, what those beliefs about teaching biology were and how they felt able to act on those beliefs in the classroom. The term 'pedagogical thinking' in the title of my study was intended to encompass the concept of teachers' personal practical knowledge, their interpretation and application of 'formal' teacher knowledge and their professional theory development. This is outlined in Chapter 2.

From my analysis and interpretation of the interview data it would seem that the early subject experiences that were having an influence on the teachers' classroom decisions were their formal experiences as pupils themselves. However, the way that they made sense of these experiences appeared to be strongly mediated by a developing empathy with their pupils' position in terms of engagement with the subject. As participants told stories about incidents with particular classes or pupils, they gave examples of how they, as teachers, saw the classroom from their pupils' perspective and were making links between this and their own experiences of being taught biology or science generally. These links were then influencing their classroom decisions.

I also considered my participants' feelings of agency in terms of their pedagogical decisions. Unsurprisingly, they discussed the barriers to this agency in terms of the content of the biology curriculum and time constraints. The issue of exam success

both for individuals and in terms of school performance were also discussed. They felt that the school context appeared to limit their feelings of agency because of this scrutiny on performance. In some responses there was also an element of assumption about what could or could not be done in the classroom rather than a response to explicit instructions from senior leaders. A factor that appeared to facilitate participants' feelings of pedagogical agency was the overt recognition of some aspect of teaching expertise, whether from colleagues in the department or more formally as a responsibility in the department. This recognition appeared to offer an element of 'permission' to be innovative and creative in the classroom.

As I worked with my data and presented my thoughts on the areas of interest that arose out of my analytical categories I began to identify an overarching theme; my understanding of pedagogical thinking and so teacher knowledge became entwined with thinking about the role of relationships in teachers' classroom decisions. This has led me to reassess conceptualisations of teacher knowledge from the perspective of relationships. In this chapter I explore conceptualisations of the role of relationships in the development of biology teachers' professional knowledge in more detail. I consider how the ideas from this study align with or differ from ideas about biology teacher knowledge in relevant literature. I also consider how they fit with more general ideas about teacher knowledge as discussed in Chapter 2.

As I noted in Chapter 1 there are only a limited number of studies that examine teacher knowledge with a focus on the specific subject discipline of biology. These include studies that have examined the responses of biology teachers to a more context led approach to the curriculum in the Netherlands, (Wieringa, Janssen & Van Driel, 2011) studies that have looked at factors contributing to 'instructional quality' (Förtsch et al., 2016) and a number of studies that have focused on the relationship

between biology teachers' subject content knowledge and their pedagogical content knowledge (PCK) (Käpylä et al., 2009, Rozenszajn & Yarden, 2014). Although limited this represents a body of relevant literature that can be drawn upon.

My study suggested that early informal experiences, such as an interaction with the natural world and an interest in aspects of science encouraged through visits to museums and science in the media, generated the initial interest in biology as a subject. It also suggested that early formal experiences, as learners of biology themselves, were significant in the formation of participants' beliefs about their subject. Early informal experiences appeared to be informing teachers' beliefs about the goals and purposes of biology as a subject in the secondary curriculum whereas the early formal experiences were discussed in terms of the impact on pedagogical ideas such as the value of practical work and a disposition towards inquiry-based approaches. My participants also appeared to be drawing on their continuing experiences as teachers of biology. This idea that beliefs about the purpose of biology teaching and an understanding of nature of the subject as a science were influenced by early experiences both, informally with the subject, and in education were similar to the findings of Rozenszajn and Yarden (2014) and Großschedl et al. (2015). Both studies argued that biology teachers' knowledge about the concepts in their subject and how to communicate these concepts was underpinned by their beliefs about the goals and purposes of biology teaching and the nature of the subject as a science and that this orientation to teaching is often related to teachers' own educational backgrounds. These experiences form part of the teachers' developing personal practical knowledge (Clandinin & Connelly, 1986) and this was not unexpected. However, where my study differed was that all the participants told stories that emphasised the role that relationships were playing in the development

of their pedagogical thinking. From my interpretation of the data, I saw relationships acting in three ways:

1. Relationships with colleagues, usually from the physical science disciplines, who considered biology as a subject to have a lower status than chemistry or physics, had the potential to negatively impact on pedagogical thinking.
2. Relationships with a variety of colleagues had a positive influence on the teachers' perceptions of how they were able to act on their pedagogical thinking, their sense of pedagogical agency.
3. Relationships with pupils that involved reflexive thinking about teachers' own experiences as learners of biology, and a recognition of similar behaviours in their pupils as learners led to a developing awareness that impacts on classroom decisions. This is a phenomenon I call 'reflexive empathy.'

This relationship between beliefs and different types of teacher knowledge and relationships is summarised in figure 6.1:

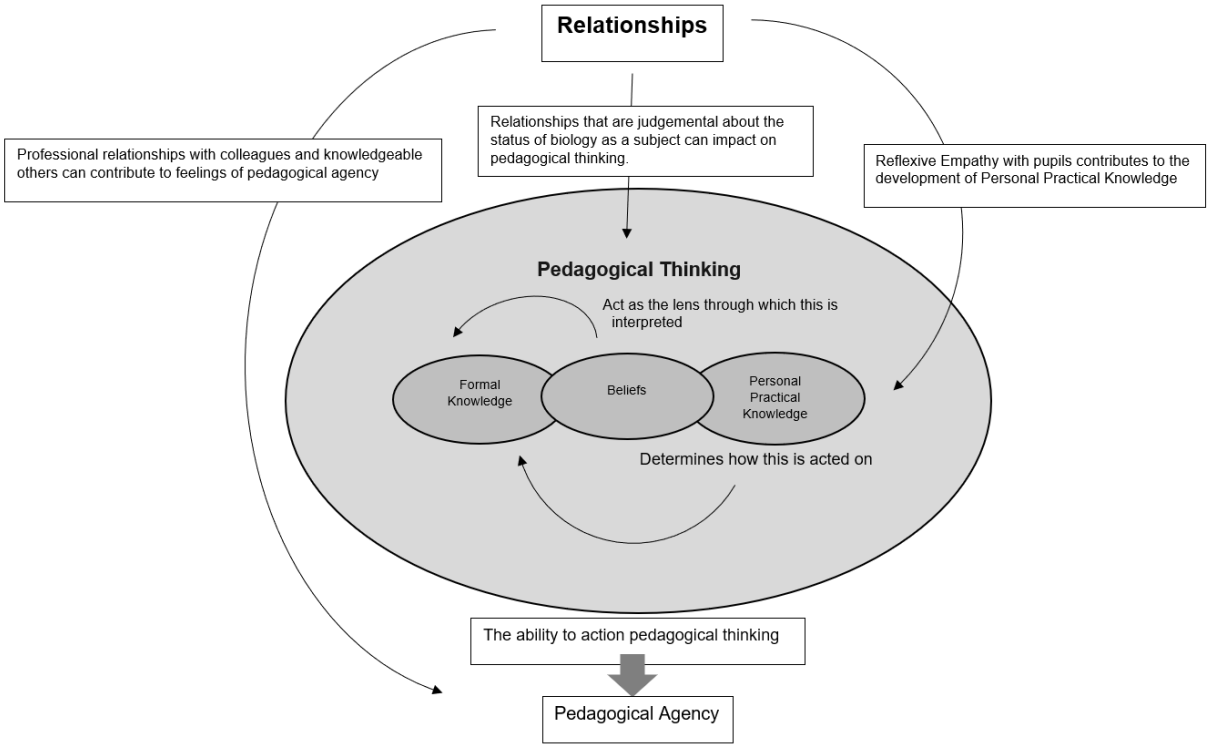


Figure 6.1 Links between relationships and teacher knowledge

I will now discuss how I see these three aspects of relationship contributing to teachers' pedagogical thinking, their personal practical knowledge, and their perception of their pedagogical agency in order to further explain the model presented in Figure 6.1.

6.2 Relationships and perceived subject status

The evidence from my study suggests that teachers hold a number of beliefs about teaching their subject but common for all of them was the feeling that biology in the secondary curriculum was a challenging and complex subject. They identified the breadth of content and the fragmented organisation of biology in the school curriculum as a challenge to their ability to teach for deep understanding. They also noted issues such as the amount of specialist vocabulary and the abstract nature of some concepts and discussions about similar subject specific issues can be found in

the biology education literature (Bahar et al., 1999, Biosciences Federation, 2005, Tunnicliffe & Ueckert, 2007). This awareness of the content and nature of the subject expressed by my participants can be considered to link to the broad agreement about the importance of subject content expertise as a factor contributing to biology teachers' professional knowledge in the literature. Some studies suggested that strong subject content knowledge could potentially allow teachers to develop a broader repertoire of classroom approaches and so contribute to PCK (Rozenszajn & Yarden, 2014) although there was also an argument for limited evidence of a direct link between specialist biology content knowledge and the teachers' ability to transform this into effective classroom decisions (Jüttner et al., 2013). Jüttner et al. also noted the importance for biology teachers of keeping up to date with their content knowledge, as biology was perceived as a rapidly evolving discipline in the 'real world.' This was evident as an important consideration for some of the participants in my study, however, in them, this awareness was also coupled with a frustration that the secondary biology programme of study in England failed to reflect some of the current developments in the subject. Where expert knowledge was felt to impact on pedagogical thinking was in the contribution to an awareness of which aspects of the curriculum would cause conceptual difficulties and misconceptions for pupils (Käpylä, Heikkinen & Asunta, 2009). My participants identified an important aspect of biology teacher professional knowledge as the developing understanding of teaching strategies that would allow complex, often abstract, concepts to be understood by pupils and how a variety of classroom approaches, including modelling, the use of analogy, inquiry-based approaches and activities outside the classroom that encouraged pupils to interact with the natural world could contribute to this. The importance of teacher knowledge of how pupils need to be supported to

develop a deep understanding of concepts and connections between them was also identified by Chapoo, Thathong & Halim (2014). Closely linked to this is the idea that biology teachers develop knowledge of how to plan classroom activities that encourage pupils to carry out more conceptual analysis, how to plan for 'cognitive activation' (Großschedl et al., 2015) something that resonates with the comments on inquiry approaches to lessons described by Dan and Emily in this study.

The additional insight gained from this study on teachers' beliefs about biology as a subject came from the fact that all the participants described their experiences of colleagues who perceived biology as a subject of lower status compared to the other sciences. There appears to be very little discussion of biology subject status in the literature. In addition to the studies that examined the nature of biology as a subject and the challenges identified in teaching it discussed in Chapter 1 (Bahar, 1999, Tunnicliffe & Ueckert, 2007), issues of status can be found by implication in studies that examine biology students' preparedness for higher education and beginning biology teachers' perceptions of their subject (Subramaniam, 2014, Kelly-Laubscher, 2016). There is also some suggestion that science students consider physics to be mathematical, abstract, and universal in application while viewing biology as concrete, qualitative and requiring the recall of numerous facts (Agutter & Wheatley, 2008). None of these studies really address the impact of these perceptions when considering a scientific *community*, so there is little written about the impact of relationships between specialists, suggesting that this study is offering an insight into an aspect of biology teachers' beliefs about their subject which may be worth further study.

In this study the relational aspect of subject status was evident in the stories that my participants told of peers in the science department making assumptions about the

characteristics of biology and how biology was taught in schools and, interestingly, for one participant this view of the subject's status by school senior leaders was used negatively in discussions about results and performance. This aspect of relationships had the potential to impact negatively on the teachers' pedagogical thinking but appeared to be having the opposite effect in this study. All of the participants in this study expressed a commitment to teaching biology for deep understanding, and although some did acknowledge that the pressure of the performance and accountability culture in school presented made them consider more strategic approaches at times, they expressed the views that strategies that supported understanding were key in their pedagogical thinking. This has led me to speculate that the overt comments from colleagues about the lower status of biology may be acting as a driver for the teachers to reflect on the nature of their subject and encourage them to ensure that they continued to develop and adopt pedagogies that support deep understanding of concepts.

6.3 Relationships and teachers' perceptions of pedagogical agency

The second way that I will argue for the impact of relationships on teachers' pedagogical thinking centres on the teachers' perceptions of how they are able to enact that thinking in the classroom. I refer to this as their perceptions of their pedagogical agency. As I discuss my findings, I will use relevant literature to clarify conceptions of teacher agency.

In my study the participants told different stories about their perception of their pedagogical agency, sometimes these were contradictory within the same interview. All the teachers felt the weight of exam success and results as an influence on their capacity to teach the way that they wanted to and one of the common responses to

the GCSE reforms was that it would limit their confidence to enrich the programme of study in the way that they usually would (see Chapter 5, section 5.6) On a subject specific scale this could be seen as a typical response of 'curriculum narrowing' in a high stakes performativity culture (Berliner, 2011). Emily discusses this in the wider context of the whole school curriculum when describing science as 'the forgotten core subject' and describes how science curriculum time is lost to mathematics and English when pupils are felt to be underachieving in these subjects (Chapter 5, section 5.4.2). It appeared in this study, that some feelings of lack of agency were due to assumptions about what was possible in the school context rather than any explicit guidance on classroom approaches provided by the leadership of the school. Several of my participants expressed beliefs about the importance of teaching biology through investigative approaches to foster curiosity and scientific thinking in their pupils, but not all of the participants felt able to act on this belief. At the time of the study none of the schools imposed a specific pedagogical approach or detailed lesson structure on the science departments but participants, particularly Arron, talked about 'what was expected' when planning lessons and also suggested that concerns about his school's performance in the region was a potential barrier to his classroom approaches: *'… we can't afford <u>as an institution</u> to, to just sort of say well, you know 'let's do a bit of exploring…'* (Arron, Interview 2)

In this respect the findings of this study resonate with situated conceptualisations of agency even if the participants were making *assumptions* about the contextual constraints. In a review of literature on teacher agency Priestly et al. (2015) argue that although many studies consider agency incidentally when discussing issues such as professionalism, educational reform, and performativity, very few focus on agency specifically. Often, they note, agency is linked to discussions around

creativity and innovation in the classroom. The notion of agency is closely related to that of professional identity in that teachers construct an understanding of who they are within their school context and carry out actions that align with this (Buchanan, 2015) and although early experiences play a role, Priestly et al. (2015) argue that many theorisations of agency appear to view it as an innate characteristic of individual teachers. Alternatives to this view are that agency is always mediated and is an interaction between the structures of the school context and the individual teacher (Lasky, 2005, Priestly et al., 2015). In this view agency is seen not as an inherent characteristic of an individual but as an action, something that teachers do (Biesta et al., 2015). Priestly et al. refer to this idea of situated agency as an 'ecological approach' to agency. From this perspective, agency is characterised by an understanding of how past experiences might shape action, a motivation towards future possibilities and is enacted in the present context, but it also has a material dimension in that it may be shaped by physical resources and is mediated by context (Watson, 2006, Buchanan, 2015, Priestly et al., 2015). Priestly et al. (2015) also argue that agency and action are conceptually distinct, with agency representing an intentionality, a capacity to formulate different courses of action. Again, in this study participants such as Arron and Becky described wanting to include more enriching and investigative approaches demonstrating an intent to enact their pedagogical thinking but felt that they were constrained by issues that were beyond their immediate school context.

However, in this study the participants also told stories where they clearly felt that they did have agency, and this seemed to link with relationships that they had with colleagues. One thing that appeared to 'free' teachers from assumptions about what was expected in terms of pedagogy was an explicit recognition of expertise, even if

this was informal. In some cases, such as Chris' second school, this was clearly part of the ethos of the whole school but in other examples the teachers were working with peers, a wider community of teachers or were recognised as experts in other aspects of their teaching and this appeared to engender feelings of agency within their subject teaching even when they recognised the need to modify their approach temporarily due to the challenges of new GCSE specifications and assessment procedures. Fitting within the concept of ecological agency is the importance of relational connections and Priestly et al. draw on the work of Edwards (2007) to introduce the concept of relational agency as part of their 'ecological' model. Edwards defines relational agency as '*a capacity to align one's thoughts and actions with those of others in order to interpret problems of practice'* (Edwards, 2007, p. 169). In many science departments and wider school contexts there will be a sharing of culture and aspects of identity that supports the development of teacher professional knowledge and shapes agency, and Edwards (2007) stresses the importance of these professional relationships to facilitate action. She argues that reforms in English schools and elsewhere have emphasised the accountability of individual teachers and strengthened the procedural aspects of teaching causing professional agency to be constrained. In her study she found that early career teachers rarely asked for help, and she proposed that this limited the development of teacher knowledge. She argued that relational agency leads to professional learning as it encourages an examination of new approaches to teaching. Linked to the concept of relational agency in this study is the role that professional relationships appeared to play in the participants' perceptions of their own pedagogical expertise. Arron and Dan both discussed working with wider groups of subject experts through social media or as part of an editorial team and both felt that they were able to

contribute expertise to these groups. Emily and Becky discussed working with biology teacher colleagues to share good practice and develop their teaching approaches and Chris was given a formal role in disseminating pedagogical ideas to his department (see Chapter 5 Section 5.7) Studies suggest that teachers who perceive themselves as having agency also identify themselves as pedagogical experts and that they will intentionally interact with others as a resource for learning (Toom et al., 2015, Tormey & Wallen, 2019). In this study all the participants shared examples that reflected their willingness to become involved in sharing ideas for classroom approaches with colleagues from within their school and in the wider teaching community.

It is worth noting another point made by Priestly et al. which is that agency is not always easy to identify; teachers may be working in creative and innovative ways within the context of their departmental or school structures but may not actually be demonstrating high levels of agency whereas individuals with high agentic capacity may find themselves limited by their context. They acknowledge that a teacher's individual capacity for agency is important and link the development of this capacity to teacher knowledge and beliefs, stating that it is important for Initial Teacher Education and Continuing Professional Development to develop innovative and questioning mindsets in teachers. To me this strengthens the argument for encouraging beginning teachers to work more collaboratively with experienced colleagues in order to plan classroom approaches for specific groups of pupils, as through these professional discussions pedagogical thinking can be made explicit.

The influence of relational working also seemed to offer opportunities for participants to reflect on their personal practical knowledge and begin to theorise it, producing professional theory (Mannikko & Husu, 2019) as discussed in Chapter 2. In this

study the participants demonstrated this theorising of practical knowledge to different degrees (see Chapter 5 Section 5.7) Chris' work with a consultant appeared to have a significant impact for him on reflection and subsequent theorising of practical knowledge. Chris described both, working with the consultant in a group of staff to examine ideas about knowledge and misconceptions, and working alongside the expert with his own classes to look at pedagogical approaches. Teacher professional development is conceptualised by Clarke and Hollingworth (2002) as opportunities for learning that are embedded into a teacher's ongoing work, the important factor being that the work is contextualised, and this seemed to be a key factor in the effectiveness of the intervention that Chris experienced. The work appeared to have similarities to the emancipating / enhancing mode of action research suggested by Berg (2001 cited by Bevins & Price, 2014) in that it was supporting Chris to understand the specific challenges of science / biology teaching within his school context. This seemed to be further enhanced by the fact that the school were actively supportive of this work and that Chris was being recognised as part of a, now more expert, team who could disseminate pedagogical approach ideas to other staff in the department. I was aware of the resonance between this example and a very similar experience in my own teaching career which might lead me to attribute additional significance to it. However, to me this example of working with an external knowledgeable other to examine pedagogical approaches seemed to be a very powerful example of developing teacher knowledge, professional theory and demonstrating relational agency. The implications for this way of working seemed even more significant when I considered that, when asked about their experiences in the pre-service (PGCE) year, participants remembered very little in terms of pedagogical development, suggesting that the pre-service year is not always the

most effective time for this deeper exploration of pedagogy. This type of opportunity would seem to facilitate the reflection discussed by Mannikko and Husu (2019) and allow personal practical knowledge to become personal theory. However, in addition to working with someone in the classroom there are other contributing factors to the success of this approach; the school culture was highly supportive of professional development and willing to fund it for the staff where appropriate and there was the element of formal recognition of expertise and a role in working with other colleagues. Although this aspect of my findings offers does not break new ground it does reinforce the concept of relational agency (Edwards, 2007, Priestly et al., 2015) and suggests a way to facilitate agency within the school context by increasing teachers' repertoire of classroom approaches and strategies, encouraging them to engage with underpinning theory and most importantly offering the 'permission' to be innovative in terms of pedagogy.

6.4 Relationships with pupils as learners of biology

My conception of the final way in which relationships appeared to contribute to teachers' pedagogical thinking arose from my analysis of the aspects of the teachers' stories that illustrated their relationships with their pupils. I argue for the significance of an interaction between the past experiences of teachers as learners of biology themselves and a recognition of behaviours in their pupils that leads the teachers to purposefully consider how their pupils are feeling about being learners of biology and what classroom approaches are appropriate to support them. This interaction leads to a conscious review of their own pedagogical thinking by the teacher. I call this relationship between the teacher and the pupils that they are teaching, a relationship which is situated specifically in the subject being taught and how it might be taught, 'reflexive empathy.'

It is widely accepted that teacher practical knowledge also includes a developing awareness of pupils' understanding in a particular subject (Elbaz, 1981, Clandinin & Connelly, 1986). This includes attention to common subject specific misconceptions and the concepts that pupils might find difficult. In this study the participants all included stories that described knowing their pupils in this way for example, Becky describes potential confusion with vocabulary and Arron describes difficulties with abstract concepts in their first interviews (Section 5.4.1). However, in some examples this appeared to go much deeper than an understanding of behaviour, motivation, or challenging aspects of biology. The literature also highlights the importance of tacit aspects of biology teacher professional knowledge that I consider to be components of personal practical knowledge such as the relationship between specific concepts, suitable pedagogical approaches and the specific groups of pupils being taught. Wieringa et al. (2011) refer to this knowledge as a teacher's 'rule of thumb', tacit ideas about what an effective lesson should include. This concept resonates with the notion of 'case knowledge' identified by Guerrero (2008) which is discussed in Chapter 2. There was evidence from my study that these tacit 'rules of thumb' may also include some *assumptions* by teachers about what a good lesson must look like in their context.

A final consideration, in terms of biology teacher knowledge, that is briefly mentioned in some of the literature is a knowledge about the pupils themselves including how pupils at different levels might understand certain concepts, the analogies and contextual links that would work with particular groups of pupils and the importance of the emotional dimension to learning a complex subject (Wieringa et al.,2011, Chapoo et al., 2014, Gess-Newsome et al., 2019). It is within this domain of teacher relational knowledge; linking subject content knowledge, PCK and a deep

understanding of the specific individuals being taught that my study adds to the understanding of biology teacher professional knowledge.

Participants all, at some point in their narratives, made connections between their own personal experiences as learners of biology (or science) and the pupils in their classes. These connections appeared to have an affective dimension as the teachers talked about their experiences compared to those of their pupils. The concept of empathy arose as an area of interest as I analysed the data and I introduced it in Chapter 5, defining empathy as an ability to take the perspective of the pupils and to consider the emotions generated by that perspective (Bouton, 2016). The teachers in my study appeared to be describing empathy as they shared stories that I interpreted as 'recognising the younger me' in a pupil or pupils. For most participants this was in the context of an aspect of biology as a subject, but it was not limited to this. Arron's experiences of being manoeuvred into taking science subjects for career reasons appeared to lead to his view of biology as a 'gateway' subject that might improve pupils' life chances but also a recognition that sometimes you should choose to do what you love. (See Chapter 5, Section 5.) This involved not just getting to know pupils' specific needs and interests but also highlighted how a teacher's reflection on personal experiences as a learner of the subject can lead to an emotional connection with the experiences of their pupils, to a recognition in Zembylas' words that '*the other is like me'* (2005).

The idea that 'knowing pupils' is an important aspect of teacher knowledge is not new. Hollingsworth et al. (1993) were some of the first researchers to make knowledge claims about what a teacher knows through being 'in relation' to pupils. Hollingsworth et al. recognised that relational knowing was an important aspect of teacher knowledge and linked it to caring. There has also been an increasing interest

in studies that have focused on empathy in a classroom context although these have often focused on culturally diverse contexts (Warren, 2013, Meyers et al., 2019) or empathy education for pupils themselves (Cooper, 2004). The kind of empathy described by teachers in my study seemed to link to Cooper's concept of 'profound empathy' (2004, 2010), that is, an ability to create a rich mental model of their pupils that they can relate to both cognitively and emotionally. In order to do this teachers draw on their own experiences and connect these with a knowledge of the pupils that they teach. All the participants described examples of this (see Chapter 5 Section 5.7). When sharing this with me one participant recalled telling a particular pupil '*You're literally me when I was your age.'* In all my participants' stories about recognising themselves in pupils they used language that suggested 'caring' as an underlying characteristic of their teaching. The findings from my study suggest that teachers' own personal and professional experiences are an important resource for such empathy.

A number of researchers do consider the affective domain in teacher knowledge. Hobbs (2012) examines the aesthetic dimensions of subject teaching and notes that a teacher's personal emotional response to the subject is an important factor in how they situate themselves professionally. Zembylas (2005) offers an important link between what is written in terms of learning theories and development of teacher knowledge, arguing that if emotion as well as cognition is considered important for pupils' learning then the same must be true for teacher learning and development. Other studies focus on the concept of emotional labour in a teacher's professional life. 'Emotional labour' refers to the challenges that teachers might face in modifying their own emotions to ensure that they are advancing pupil progress and enacting caring teaching (Isenbarger & Zembylas, 2006). However, none of these studies

seem to be suggesting the connections that my participants were describing. My participants in different ways were describing how a reflection on their own experiences as learners triggered a recognition, an emotional response, and an empathy with their pupils. Lasky (2005) suggests that experiences of emotion are closely connected with the development of beliefs, and it appeared that these moments of connection were also prompting reflexive thinking in that there was evidence that the participants were then considering their classroom approaches, prompting an inner dialogue (Freucht et al., 2017) that was influencing their pedagogic thinking. I argue that reflexive empathy generated by these moments of emotion, empathy, recognition and connection with pupils and reflexive thinking around the subject offer an important contribution to teachers' personal practical knowledge and professional theory.

6.5 The centrality of relationships to teachers' knowledge

The insights that I have gained from this work have allowed me to argue for the importance of relationships in the development of teacher knowledge. The study also adds to the knowledge of the beliefs held by teachers about teaching biology.

- Teachers' early informal experiences with biology are contributing to their beliefs about the *purpose* of the subject in the curriculum.
- Biology teachers believe that there is a perception that their subject has lower status than the physical sciences and that this can be a challenge for them within science departments.
- Relationships appear to be a key factor contributing to teachers' personal practical knowledge and professional theory, which form part of their

pedagogical thinking, and their perception of how they can act on their pedagogical thinking in the classroom. Particularly significant are:

- Moments of reflexive empathy, where teachers connect their own experiences as learners to the experiences of their pupils have the potential to positively influence classroom approaches.
- Working with others, either formally or informally can have a positive impact on teachers' perceptions of their pedagogical agency.

6.6 Chapter Summary

This study argues for the importance of relationships in the development of teacher knowledge and the ability to act on that knowledge. Knowing through relationships is considered central to teaching (Clandinin, 1985) and it is understood that teachers will interpret and understand their pupils' actions in a way that is unique and based on their prior personal experiences (Nias, 1996). Entwistle et al. (2010) also talk of an emotional understanding of pupils and suggest that teachers will habitually check the pupils in their class for engagement and response. Although 'knowing pupils' has always been considered an important aspect of teacher knowledge in much of the literature this knowing tends to refer to an understanding of pupils' preferred learning approaches, prior knowledge, specific needs and misconceptions in the subject. My findings concur with earlier studies from the 1990s about the importance of knowledge that is gained from being 'in relation' with pupils and the need to recognise an affective dimension to this knowledge. My findings suggest that a significant way of knowing pupils that incorporates an affective dimension happens when a teacher reflects on their own experiences as learners of biology and develops a recognition of, and an empathy with, the learners that they are working

with which in turn impacts on their classroom decisions. I refer to this as reflexive empathy. I argue that this study adds to an understanding of how teachers 'know' pupils in that it demonstrates links between explicit reflection on teachers' own experiences as learners and a connection to the emotional aspects of that experience with a recognition of behaviours and characteristics of their pupils leading to an empathy with the pupils as learners of biology that influences pedagogy.

I situate personal practical knowledge as part of the teacher's professional learning and acknowledge that reflection is an important part of how this knowledge can develop to form personal professional theory. From the literature it is considered that the personal aspect of this knowledge originates in early experiences with the subject, both informally and more formally as learners of biology themselves, with the practical aspect of personal practical knowledge being informed by the teacher's ongoing experiences in the school context (Clandinin, 1985, Clandinin & Connelly, 1986). However, there are difficulties in separating out personal practical teacher knowledge in this way as the findings of my study suggest that teachers' *personal* experiences as teachers are also significant. In addition to a knowledge of school structures, relationships play a significant part in the development of this knowledge. Adopting the stance that agency can be considered as situated, in that it is not a characteristic of an individual but is an ability to act mediated by the school context, I argue that context and importantly relationships within that context are key to determining how teachers feel able to enact their beliefs and values about teaching biology. Relational working with colleagues or knowledgeable others appeared in the teachers' stories and these relationships appeared to offer a validation of the teachers as continually developing classroom experts and offer, even if informally, the permission to be innovative when planning lessons. The teachers recognised

barriers to innovative approaches such as concerns about new assessment procedures, the content heavy programme of study and the need to achieve results in high status testing, but in most cases discussed ways in which they could work creatively within the constraints that they felt. I also think that this study provides evidence of an argument to be made for approaches that give teachers a strong voice in in research into their pedagogical thinking.

In the next chapter I will outline my conclusions and consider the implications for practice arising from this study. I will also evaluate my work and consider possible areas for further research.

Chapter 7: Conclusions, implications for practice, evaluation, and ideas for further study.

7.1 Introduction

I began this study with three research questions and an underlying anxiety about the current situation in secondary biology teaching. The aim of the study was to try to understand the experiences of a small number of practising biology teachers, not in order to make general claims, but to gain some insight into the factors that they felt were influencing their decisions as subject teachers. In this final chapter I include the summary of my contribution to knowledge from Chapter 6 as a starting point and I outline my conclusions as they relate to my original research questions. I then consider the implications for practice both for biology teacher educators and more widely for teacher education programmes and early career entry support. I then evaluate my study, outlining possible areas of further interest and study.

7.2 Contributions to knowledge

Before discussing each research question in more detail, I will summarise how this study has contributed to knowledge:

Research question 1: What are biology teachers' expressed beliefs and values about teaching their subject?

This study has provided valuable insights into the beliefs of biology teachers, an under researched group.

1. Biology is recognised as a complex and challenging subject to both teach and learn. The challenges that were perceived in the subject were related to the breadth of the content in the secondary curriculum and the diverse nature of

biology as a subject, the amount of specialist vocabulary that had to be contended with and issues with pupils' perceptions of what biology as a subject actually entailed.

2. This study also highlighted that biology teachers may believe that there is a perception that their subject has lower status than the physical sciences in the view of other science colleagues and senior staff in school and that this can be a challenge for them within science departments and when justifying pupil performance. There were also concerns about how effectively non-specialist scientists may approach the teaching of biology because of this perception. Although this had the potential to impact in a negative way it actually appeared to reinforce the commitment of the teachers in this study to teach biology for deep understanding.
3. The biology teachers in this study believed in the importance of ensuring that complex abstract ideas should be made accessible to pupils and that teaching should facilitate a deep understanding. It was felt that this could be achieved through the use of modelling and contextualising the concepts in a way that related to their pupils' experiences.
4. Practical work, including the use of dissection, was seen as an important aspect of teaching biology, particularly in terms of pupil engagement, but there was also an underlying belief for some participants that this practical work could be challenging and time consuming to plan and deliver in the classroom and if not done well could lead to misconceptions.
5. In common with a number of other studies participants expressed the importance of having an underlying vision for the goals and purposes of teaching biology as a secondary school subject.

Research Questions 2: What are biology teachers' perceptions of the way in which previous experiences with their subject have influenced their values and beliefs about teaching biology?

1. It has highlighted that teachers' early informal experiences with biology contribute to their beliefs about the *purpose* of the subject in the curriculum. Unlike other studies that found a clear link between early subject experiences and classroom approaches, the early experiences described by the participants in this study, such as an interest in natural history or an interest in human biology, seemed to be informing their beliefs about the role of biology as a subject in the secondary curriculum. Participants discussed the importance of biology in terms of health education, environmental issues and as a way of encouraging curiosity and scientific thinking.
2. It suggests that teachers' experiences as learners of biology themselves, plus their previous experiences as *teachers* of biology are having the most significant impact on their beliefs about how the subject should be taught.
3. Interestingly, participants' experiences in the ITT year did not appear to have had much impact on their beliefs about teaching biology.

Research Question 3: What are biology teachers' perceptions of how they can implement their beliefs in the classroom?

1. This study has added to understanding about teachers' personal practical knowledge by expanding on the significance of relationships. Relationships with colleagues and with pupils themselves appear to be a key factor contributing to teachers' knowledge and professional theory, which form part of their

pedagogical thinking and their perception of how they can act on their pedagogical thinking in the classroom.

2. It adds to prior work that has approached teacher agency, not as a characteristic of individuals but as situated, shaped by the school context and the professional relationships within that context.
3. It has generated the new concept of reflexive empathy to capture the way in which teachers connect their own experiences as learners to the experiences of their pupils in a way that has the potential to positively influence classroom approaches.

7.3 Returning to research questions in detail

The participants' stories contributed to my understanding of the challenges of biology teaching in the current educational context, but I also found that their stories were ones of enthusiasm for the subject and clearly expressed care for their pupils despite these challenges. Their stories made me hopeful, professionally, and privileged, personally, to have shared them. It was possible, as I interpreted the data, to identify several common areas of interest which are presented and discussed in preceding chapters. I took a grounded theory approach to this study as I had very few predetermined ideas. I will now summarise my key findings in relation to my initial research questions before discussing the possible impact on practice that these insights might suggest.

What are biology teachers' expressed beliefs and values about teaching their subject?

All the participants in this study felt that biology was a complex and often abstract subject that covered a wide range of concepts. They felt that it was made even more

challenging because of the way it is fragmented and sequenced in the secondary curriculum. They were all very aware of the challenges involved in a subject that involved the different conceptual levels that biology shows (Bahar et al. 1999) with topics that dealt with the concrete and observable being taught alongside more abstract and symbolic concepts to pupils in the same key stage. This contributed to invalid assumptions about the nature of biology as a subject. They felt very strongly that there was a need to teach for the understanding of key concepts and underlying principles rather than for short-term recall. However, it was recognised that the accountability culture prevalent in schools (Ball, 2003), externally controlled changes to the curriculum content and assessment procedures and the perceptions that both physical science colleagues, and often pupils themselves, had about it being an easy science made this an additionally challenging aim.

What are biology teachers' perceptions of the way in which previous experiences with their subject have influenced their values and beliefs about teaching biology?

Interpreting what the data might be suggesting for this research question proved extremely interesting. Contrary to a number of other studies, these participants' early informal experiences with the subject did not seem to be influencing their classroom decisions but contributed to the teachers' beliefs about why the subject was an important one in secondary schools. Early informal experiences such as an interest in natural history or the human body were clearly responsible for three of the participants' interest in biology and their decision to study the subject in higher education. Formal experiences with biology, as learners themselves, seemed to be far more influential on the participants' beliefs about teaching biology. Positive experiences with practical lessons and influential teachers were all cited as reasons

for wanting to teach in particular ways and be a particular type of teacher. In contrast to my own experiences most of the participants had positive memories of their own education, although one participant felt that the decision to study science had not really been his choice, but one advised by parents and teachers. As I worked with the data the responses that were informing me about this question appeared to suggest that relationships in the participants' current school context and the wider science teacher community were an important influence on the participants' pedagogical thinking, something that I conceptualise as a combination of their beliefs, formal knowledge about teaching biology, their personal practical knowledge, and their reflections on this knowledge. What appeared to me to be the most powerful relational influence on how they approached their biology teaching was the impact off their growing understanding of, and empathy with, their own pupils, a phenomenon I refer to as 'reflexive empathy.'

What are biology teachers' perceptions of how they can implement their beliefs in the classroom?

In terms of their perception of pedagogical agency there seemed to be an underlying perception of scrutiny from all the participants, discussions often referred to a monitoring 'they' even when there were no concrete examples of who 'they' might be. This led to some participants talking about what was expected of them in the classroom and the barriers to teaching in the way that they would like. However, professional relationships also seemed to play an important part in redressing this feeling of lack of agency. Participants described working with others to develop and share their classroom approaches and this seemed to confer 'permission' to be pedagogically experimental. These relationships were varied and included examples such as informal discussions with like-minded colleagues, the sharing of good

practice with on-line subject communities and an external expert guiding a departmental rethinking of the approach to science teaching. This resonated with the concept of ecological agency, in which agency is seen, not as a characteristic of individual teachers but as situated within the school context (Priestly et al., 2015).

7.4 Implications for practice

There are three main implications from this study for the practice of biology teacher educators and more widely in terms of Initial teacher Education and support for early career entry.

- A reconsideration of how the nature of biology as a subject is considered in relation to chemistry and physics and the wider subject support and CPD provided for biology teachers.
- A consideration of how the building of professional relationships in the pre-service year and beyond can be supported.
- A greater focus on what it means to be reflective and reflexive in terms of teaching experiences in the pre-service year.

Implications for the practice of biology teacher educators

This study represents a long, personal, professional journey and insights from this work have influenced how I approach my role as a science teacher educator in terms of the nature of biology as a subject. One of the first changes was around my introduction to biology as a subject in the early subject pedagogy days on the PGCE course. I now include a session that begins by structuring pre-service teachers' reflection on their experiences of learning biology. This is particularly relevant if they are physical scientists rather than biology specialists. This facilitates a, hopefully,

honest consideration of the variety of practice that can exist in the subject. I follow this with a session that allows pre-service teachers to see how I make sense of the subject, acknowledging the fragmented and often wide-ranging nature of the concepts that form the secondary curriculum, and then encourages them to make their own sense of it, thinking particularly about which concepts are concrete and descriptive, which are abstract and require the use of models and analogies and how concepts connect. It is only at this point that we begin to think about pedagogical approaches.

For me one of the key implications for practice as a biology teacher educator has been to spend more time focusing on the nature of biology and how it relates to the other sciences in a way that encourages pre-service teachers to consider how *they* are going to make sense of the subject.

Implications for the availability of subject support for pre-service and practicing biology teachers.

There are also implications related to the wider pedagogical support / CPD to be found for biology education. Although there are excellent materials and support provided by 'Science and Plants in Schools' and the Microbiology Society and some excellent resources produced by university sites such as the University of Utah's 'Teach Genetics,' currently there is no single point of pedagogical support for biology teaching in the same way that the Institute of Physics and the Royal Society of Chemistry support physics and chemistry teachers. The support, like the subject itself, appears fragmented.

Implications for more general practice in Initial Teacher Education programmes and early career support.

The importance of professional relationships highlighted by this study also has wider implications for practice in initial teacher education. With two clear possible models of relational support; firstly, peer support and secondly, the support of more expert colleagues. I feel that there is a strong argument to be made for the use of paired or triad placements for pre-service teachers within a school. This is not a new model, but the current shortage of science placements within the region has meant that most placements on my programme are either for a single trainee or for multiple trainees with individual timetables and mentors, effectively making them individual placements. In common with many programmes the school-based work is integrated into the course from an early stage, the idea being that learning is situated and the beginning teachers develop personal practical knowledge as they are introduced to formal knowledge from university sessions. In theory the trainees become co-learners in their school community. The reality is often less than ideal, mentors and expert colleagues are busy, pressurised by the demands of their jobs and often do not get any additional time to work with the beginning teachers in their departments. By carefully structuring paired or triad placements it should be possible to facilitate a peer coaching model (Kurtts & Levin, 2000) and provide opportunities for collaborative working that allows beginning teachers to develop more insight into pedagogy but also develops skills for working with other professionals (Goodnough et al., 2009). Collaborative working in this way could provide the opportunities for discussion that the teachers in this study found so valuable.

Relationships were the theme that underpinned the findings in my study but currently there is very limited acknowledgement of the importance of these relationships in my personal work with pre-service teachers. Beginning teachers are given guidance on how to work effectively with their school mentors but much of this guidance is

procedural. Given the potential impact of professional relationships on pedagogical thinking suggested by this study this could be given more emphasis and should include how to work with other expert colleagues in schools and how to work with their peers on the course itself. However, for this to be effective, any planning of changes in approach needs to include school partners at an early stage.

If a key part of an agentic teacher's identity is that of pedagogical expert and, as my participants suggest, that even informal recognition of this contributes to these feelings, then schools can facilitate teachers' feelings of pedagogic agency by encouraging peer discussions and collaboration within departments. Another important factor when considering how to support teachers to achieve pedagogical agency in schools is the concept of relational agency within subject groups or departments. This collaboration appears to offer an element of 'permission' to think in different ways about classroom approaches and does not always have to be formal and structured. The importance of relationships in developing a teacher's perception of their agency has implications for the early career support that could be offered within schools.

The final implication for practice concerns how Initial Teacher Education programmes can support beginning teachers in terms of their reflection on their developing personal practical knowledge. Typical of most teacher education programmes, we build reflection on lessons and progress into our documentation to support weekly mentor meetings and lesson debriefings. The aim of these documents is to guide and structure reflection on personal professional progress. However, from feedback and discussion with students it is clear that in many cases this is simply treated like another university task to complete and is carried out fairly superficially, with a focus on specific incidents or 'house-keeping' issues such as

timings or resource management, an issue identified in the literature (Feucht et al., 2017). In my experience very few students feel able to reflect deeply on their pedagogical thinking and this may be because there are issues around the multiple demands on a beginning teacher, particularly in the early stages of school placement, where the focus really is on management and timing. However, I feel that it would be possible to build on the work that I now do on the nature of biology to encourage beginning teachers to identify previous episodes from their experiences as biology learners that have an emotional significance for them and use this as the basis for a regular structured discussion that encourages the beginning teachers to reflect on behaviours that they observe in their pupils in relation to their own experiences as learners and, most importantly, consider whether this has implications for their actions in the classroom. I feel that there is an argument for discussing the dimension of empathy in becoming a teacher and I propose from the findings of this study that the idea of 'reflexive empathy' as described by these teachers should be considered as an important part of teachers' developing personal practical knowledge and should be encouraged in teacher education programmes. I suggest that focusing on moments of reflexive empathy may offer opportunities for teachers to consider different ways of approaching concepts in their classrooms. This is an area that I feel is particularly important given the current focus on knowledge to be 'retained' in the secondary curriculum and an Initial Teacher Training Content Framework that emphasises teaching strategies to aid this retention (DFE, 2019). In terms of the implications of this study for early career support in schools there may also be value in increasing opportunities for teachers to work alongside subject based experts in the way that Chris found so valuable.

7.5 Evaluation

It is easy at the end of this study to consider things that I would have done in a different way. As I read through the final work, I can clearly see my own journey particularly my struggles with data distillation and analysis which were so very different from any analysis that I had carried out previously. It felt right to code and organise by hand for this study, to be steeped in my participants' words and to reflect on my own experiences, but I can see that any larger amounts of data would require the use of a computer programme, such as NVIVO, to help with organisation, collation and producing relational diagrams.

One of my main challenges was the ontological journey that this study took me on, moving from a positivist, often quantitative way of working with data to a more interpretive and constructivist approach. Probably my biggest challenge was the unconscious and careless use of language, particularly when referring to my data analysis, which suggested an objective ‘truth’ to be discovered in the data and I found that this was something I needed to be constantly mindful of when writing this thesis.

The grounded theory approach also presented challenges. In some ways it felt very familiar and appropriate to look at what the data might be suggesting, and build up theories from this data, particularly as I had very few preconceptions about what might emerge. I found the use of teacher narratives as data exciting and it was a real privilege to share my participants’ stories, but I had not anticipated the amount of potential information that this form of data could provide. There were definitely points in the work when the amount of data and the possible interpretations felt overwhelming, and I found it difficult to be clear about how I was making connections

between ideas. The other issue that arose was how to present the data. In line with GT approaches I used coding and produced some matrices of responses against the interview questions in an attempt to distil the data but had anticipated presenting participants' narratives, even if reconstructed, as the main data. However, as I analysed the data several areas of interest common to all the participants emerged and it made more sense to consider excerpts of the participants' stories more thematically even though the sense of individuals' stories was lost through this approach.

I noted in the findings chapter, as I was discussing the theme of empathy with pupils, that my participants appeared to share a similar context with their pupils. The nature of the geographical region in which I work, rather than deliberate design, meant that all the schools in the study could be considered to be in challenging socio-economic contexts and the teachers who worked with me either came from similar backgrounds or similar areas of the country to the pupils in their schools. My conceptualisation of reflexive empathy appeared to be a very significant factor contributing to teachers' personal practical knowledge and professional theory in this study, but an important question would be whether it is a phenomenon specific to contexts where pupils and teachers have shared experiences and understanding of challenging circumstances, which leads me to consider areas for future research.

7.6 Further research

There are a number of potential areas for further research arising out of my study such as finding out more about the experiences of other biology teachers and looking at the impact of working with experts in the classroom on early career teachers' developing knowledge. However, the concept that has interested me most

is that of the role of reflexive empathy in the development of teacher knowledge and its potential impact on pedagogy. There are a number of recent studies about the role of empathy in teaching, but these are mainly centred on issues of cultural empathy when teaching in multi-cultural contexts (Barr, 2011, Warren, 2013) or teacher resilience in challenging UK schools (Day & Hong, 2016). It would be useful to expand this study to specifically look at the concept of reflexive empathy as suggested by my study. I would be interested to explore whether, and if so, how this phenomenon is experienced by other teachers, and by teachers of the other subjects. As mentioned in the section above, I realised that my participants had direct connections with the school contexts that they were teaching in, either as former pupils in the actual school that they now worked in or because their own secondary education had taken place in a very similar context. Without intending to do so I had also selected to work with participants from school contexts that could be considered challenging with high levels of socio-economic deprivation in their catchment areas. Because of this several ideas for further research would seem appropriate:

- Is there a link between shared experiences of context as learners and the ability to demonstrate reflexive empathy?
- Are subject experiences enough to generate reflexive empathy or is context the most important factor?
- Can reflexive empathy be encouraged in pre-service teachers and how might this be facilitated?

Personal story: Reflexive Empathy

I started this thesis with a personal story, so it seemed appropriate to end it on one. As I wrote the discussion for this study, I found myself thinking about reflexive empathy as I had defined it and wondering what *my* experience of this as a teacher had been. I had already considered a couple of instances in my experiences as a pupil of biology that had shaped my beliefs about how to approach teaching - one of these can be found in appendix 5b - but they did not seem to be quite the same as the phenomenon I was describing in Chapter 6. Then it hit me. My moment of reflexive empathy was so big for me personally and influenced my whole approach to the teaching of an aspect of biology, that I had almost failed to recognise it. It was emotive as it involved reflecting on quite an unpleasant experience, but it definitely, consciously impacted on my pedagogy. I end therefore, with what I feel is my main moment of reflexive empathy as a secondary school teacher.

I have already described how I felt like the biology that I loved and was interested in was something separate to the experiences I got as a pupil at secondary school but despite that I opted to study all the sciences at A-level including biology. Towards the end of the first year of the course we went on a field trip to the coast in North Yorkshire. There were only three or four of us doing A-level biology and I remember thinking that this would be really good, finally some proper outdoor biology, the chance to look at creatures in rock pools, identify things – it was exactly what I loved doing and I would be with someone who could help with identification – I would learn things! The first couple of days were really good, it was exactly as I had hoped in that we looked at the organisms that lived in rock pools, looked at how things were

distributed … I didn't even mind too much when we did a huge transect of the beach. With only a few of us it took ages and even I became a bit overwhelmed with the repetition and tedium.

We then got an opportunity to do a real field investigation. We were actually thinking about variables and designing an investigation – proper science! Except we weren't. We were told what we would be doing and how we would do it. The 'investigation' involved measuring limpet tongues at different points on the shore. I have no idea why or what we were trying to find out because it turned out that the way that you carried this experiment out involved killing the limpets first. All I really remember about that field trip was sitting in some small kitchen, in whatever accommodation we were staying in, while limpets boiled in a pan and three or four seventeen-year-old biology students became more and more nauseated and appalled by this 'investigation'. Why were we destroying creatures? What was the point? I actually find it very difficult to look back on because I now know that there are all sorts of measurements that you can do on limpets without hurting them. But it was a different time and a different sort of school experience, and it wouldn't have occurred to any of us to mention it at home. It was probably the experience that made me choose aspects of biology that didn't require the exploitation and injury of other species when I did my degree. Anyway, fast forward to me as a biology teacher, after my second year at the school staff changed, people got promoted and a close colleague and I found ourselves in charge of the A-level biology course, and this included the field trip. We decided that we wouldn't pay lots of money to someone to do the activities, but we would teach the whole thing, we would go to the Gower Peninsula as my colleague had carried out her Open University field investigations there (she was a recent conversion from PE to biology teaching). As we sat and planned the

work two things came to me: firstly, my experiences with GCSE field work as a newly qualified teacher, watching pupils get bored and restless while collecting repetitive data, and my horrible experiences on my own field trip. I decided that we needed to make the field work as varied and exciting as possible, because not everyone wanted to stand around identifying seaweed for hours – so we investigated lots of different areas on the peninsula in order to plan the experience: salt marshes, freshwater streams in meadows, woodlands, sand dunes and of course the rocky shore. I also decided that no field work would ever take place without a formal ethical consideration before-hand, pupils needed to be aware of their responsibility to do no harm while working with species in the environment. So, we planned it and ran the first one. The first few days were about teaching sampling and analysis techniques and the final two days were out aside for pupils to carry out their own investigations. We deliberately made techniques for collecting large amounts of data, such as transects, a collaborative exercise, so that pupils weren't bored by what they perceived as pointless repetition. We considered the different interests of people, so we taught them how to gently catch crabs, sex and measure them, how to compassionately catch, count and release the lightning fast, transparent shrimps from the rock pools, how to spot sea anemones hiding on the edges of polls and how to kick sample rivers without hurting anything as well as the more traditional techniques. We worked so hard at catching their interest and stimulating curiosity – we pounced on questions, so if anyone asked a casual question about the habitat that we were working in, perhaps, 'are the crabs bigger nearer the sea?' We would immediately ask; how can you find out? Why don't you find out? I loved those field trips. I don't think any of the pupils hated them, no organisms were killed, some real science happened because the questions that were being investigated were

authentic, as teachers we often didn't know what the answer would be. So, there it was … my reflexive empathy … and I still feel its emotional impact even after more than ten years as a teacher educator rather than a biology teacher.

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Appendix 1: Copy of the Consent form

Pat Moore
07583163241
p.moore@shu.ac.uk

Please read this information carefully and complete your responses if you are willing to take part in the 'Biology Autobiography' research study.

Name:

Date:

Email address(es): ***Phone number(s):***

Please answer the following questions by circling your responses:

Have you read and understood the information about this study?

Yes No

Have you been able to ask questions about this study?

Yes No

Have you received enough information about this study?

Yes No

Do you understand that you are free to withdraw from this study at any time up to the point of final writing up?

Yes No

Do you understand that you do not need to give a reason for your withdrawal?

Yes No

Your responses will be audio recorded for transcription purposes and the original audio files deleted after the transcription process.
Do you give permission for the audio recording of your responses?
Yes No
Do you give permission for copies of the photographs that you provide to be

used anonymously in published materials/research reports?

Yes No

Do you have express permission from any human subjects that have been photographed for this project that their images can be reproduced in research materials/reports?

Yes No

Do you agree to take part in the study?

Yes No

Your signature will certify that you have voluntarily agreed to take part in this research study having read and understood the information sheet for participants. It will also certify that you have had sufficient opportunity to discuss the study with a researcher and that all questions have been answered to your satisfaction.

Signature of participant

Date

Name (block letters)

Signature of researcher

Date

Researcher contact details:
Pat Moore
Owen 949
City Campus
Sheffield Hallam University
Sheffield
S1 1WB
Tel: 0114 225 6205
e-mail: p.moore@shu.ac.uk

Please keep your copy of the consent form and the information sheet together.

Appendix 2: Sample of Image and transcription from Arron Interview 1

Arron: Er... ten is er a skeleton made out of buns which was something a Polish student in year 7 brought in for me a few years ago
P: It's brilliant
Arron: er …he was part of our science club and part of our group that we actually brought through for Chain Reaction … and er he was really interested in muscles and movement and so one evening after science club I think it was I just sat down with him and talked through a few bones and a few muscles and he er the next week I think it was the week before Christmas he came in and he'd done this... and I just thought it summed up the imagination that the year 7s have
P: Yeah, almost that thinking outside of things that we would normally assess
Arron: Yeah, also that would be completely an anathema to many of the current, I don't know, awarding bodies. They wouldn't think to, to reward creativity in that way … and an awful lot of, you know, this boy's a polish boy, he's instantly up against it as far as exam, because of his lack of English and yet he clearly has a very good understanding of the structure of the skeleton … Er and I think as biology teachers, examiners and professionals and we need to find an alternative way of examining because exams don't suit the modern age

Appendix 3: Confirmation of ethical approval for the study

Sheffield Hallam University

Our Ref AM/KW/D&S-108
10 August 2015

Pat Moore
Faculty of Development and Society
Sheffield Institute of Education
Room 949
Owen Building
Howard Street
Sheffield
S1 1WB

Dear Pat,

Request for Ethical Approval of Research Project

Your research project entitled " **Biology Autobiographies: how do personal subject experiences influence biology teachers' pedagogical thinking?**" has been submitted for ethical review to the Faculty's rapporteurs and I am pleased to confirm that they have approved your project.

I wish you every success with your research project.

Yours sincerely

Professor A Macaskill
Chair
Faculty Research Ethics Committee

Office address :
Business Support Team
Faculty of Development & Society
Sheffield Hallam University
Unit 4, Sheffield Science Park
Howard Street, Sheffield, S1 1WB
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Appendix 4: Open codes generated for the interviews

Memo 1

Coding the text against the research questions

What are biology teachers' expressed beliefs and values about teaching their subject?	
What are biology teachers' perceptions of the way in which previous experiences with their subject have influenced their values and beliefs about teaching biology?	
What are biology teachers' perceptions of how they can implement their values and beliefs in the classroom?	

There are a number of common areas being discussed in all the initial interviews:

- ***The use of practical work - comments were both positive and negative. Dissection activities in particular are commented on.***
- ***Formal examinations and their influence on classroom practice.***
- ***Vocabulary as a barrier to conceptual understanding.***
- ***The importance of modelling from both a teacher and pupil perspective.***
- ***Participants D and E had clearly spent time considering quite deeply about what they felt was important in biology teaching and gave very <u>coherent</u> accounts.***
- ***Participant E sounded very nervous initially - there are gaps and I contribute slightly more than in other cases in an attempt to relax and draw them out.***
- ***Participant E is clearly constructing their answers as they respond - you can almost hear it!***

The next step in this initial phase was to carry out some open coding of the scripts in order to identify distinct ideas and an initial tally of the number of times the idea is mentioned. These are noted in the order that they first appear in each transcript.

Open coding memos interview 1

Participant A

Idea	***Number of times mentioned***
Modelling abstract concepts	*4*
Pupils reshaping information	*1*
Importance of exam success	*3*
Teacher perception of concepts / content in the curriculum	*3*
Human physiology as a concept	*1*
Biology in relation to studying medicine	*2*
Importance of real-world applications	*2*
Problem solving	*1*
The impact of an inspirational event	*1*
Biology in relation to sport	*1*
Practical dissection - negative	*2*
Relevance of the subject to pupils	*2*
Biology as an evolving subject	*2*
The importance of Chemistry	*1*
Collaboration	*2*
The importance of new technology in the classroom	*2*
Assessing pupils' understanding of the subject	*2*
Awareness of external ideas about good teaching	*1*
Creativity when teaching	*3*
Vocabulary as a barrier	*1*
Choosing to learn a subject because you enjoy it	*1*
Wanting to teach another subject	*1*
The route to becoming a teacher	*1*

Immediate thoughts

- ***Teaching is in the family***
- ***Trained to teach a different science (Chemistry) because of financial incentive***
- ***Employability concerns***
- ***Identify as a science teacher rather than a biology teacher***
- ***Now teaching physics***
- ***The importance of using models and analogies to help pupils understand ideas came through very strongly.***
- ***A tension - exam success is key, but the system disadvantages some pupils. The need for more creative ways of assessment.***

- ***Negative feelings about the role of practical work in the subject. Unnecessary?***
- ***Negative feelings about teaching concepts around plant biology.***

<u>Participant B</u>

Idea	***Number of times mentioned***
Vocabulary as a barrier	*4*
Practical dissection - positive	*3*
Practical dissection - negative	*2*
Challenge of teaching abstract concepts	*1*
Modelling abstract concepts	*2*
Constant reinforcement of ideas with images in the classroom	*1*
Creativity when teaching	*2*
Teacher perception of concepts / content in the curriculum	*5*
Identifying 'Cells' as an underpinning concept	*1*
The importance of multiple approaches	*1*
The importance of connecting concepts	*1*
Pupil engagement	*3*
Other's perception of biology as a subject	*2*
Importance of exam success	*1*
Relevance of the subject to pupils	*2*
Perception of self as a biology specialist	*1*
Limited opportunities for practical work	*1*
Wider definition of practical work	*1*

<u>Immediate thoughts</u>

- ***Committed to practical work but feels that opportunities can be limited***
- ***Negative feelings about teaching concepts around plant biology***
- ***Importance of pupil engagement and participation***
- ***Technical vocabulary as a barrier***
- ***Importance of understanding cells as a key concept.***

<u>Participant C</u>

Idea	***Number of times mentioned***
Importance of exam success	*1*
Barriers and difficulties with practical work	*15*
Modelling practical approaches	*2*
Pupil engagement and participation	*1*

Practical work and engagement	*2*
The importance of new technology in the classroom	*1*
The importance of using real biological material	*1*
Relevance of the subject to pupils	*1*
Practical dissection - positive	*3*
Teacher perception of concepts / content in the curriculum	*4*
Importance of real-world applications	*1*
Limitations of whole class teaching	*1*

Immediate thoughts

- ***Initially very positive about practical work but a large number of comments are made about the barriers and problems with practical work in biology (at one point compared to the ease of doing practical in physics)***
- ***Positive about the use of biological material - plants, dissection***
- ***Felt it was important to expand on basic concepts and relate these to the real world***

Participant D

Idea	***Number of times mentioned***
Dissection - positive	*3*
Practical work - positive	*2*
The importance of enquiry and pupils curiosity	*3*
Teaching science process	*8*
The importance of collaboration	*10*
Importance of real-world applications	*10*
Pupil engagement	*8*
Opportunities for out of classroom / school learning	*5*
Importance of exam success	*2*
Modelling practical approaches	*1*
Application of understanding in different contexts	*3*
Vocabulary as a barrier	*1*
Developing transferable skills with pupils	*1*

Immediate thoughts

- ***The importance of understanding about the scientific method and following correct procedures - this included some thoughts about addressing the ethical issues of dissection with pupils***
- ***The importance of linking to real world science and giving opportunities for genuine enquiry and research.***

- ***The importance of showing pupils with limited opportunities different experiences and working outside the classroom.***
- ***The importance of getting pupils engaged.***

Participant E

Idea	***Number of times mentioned***
Defining biology teaching	*2*
Importance of the environmental / wider world connection	*8*
The importance of using real biological material	*9*
Biology as it links to health education	*4*
Opportunities for out of classroom / school learning	*4*
Pupil engagement	*1*
The route to becoming a teacher	*2*
Dissection - positive	*1*
The importance of enquiry and pupils curiosity	*1*
Reasons for wanting to teach biology	*2*
Barriers and difficulties with practical work	*1*

Immediate thoughts

- ***Conceiving biology as a study of the environment and its connections. The importance of this.***
- ***Positive about using plants as exemplar material in the classroom.***
- ***The importance of biology and its links to health education.***

Initial comments at this stage

- ***Not all participants mentioned previous subject experiences at this stage***
- ***There were a lot of comments that explored beliefs about biology teaching***

Can these initially identified ideas be synthesised into themes?

Theme	***Colour code***
The use of models and analogies	
The use of practical work	
The use of enquiry approaches	
Other pedagogical approaches	
Perception of self as a subject specialist	
Wider importance of biology as a subject	
Perceptions of biology as a subject	

Open codes for Interview 2

Biology teaching not first choice
Not making the grades
A number of unsuccessful choices
Physics CPD once qualified
Accountability - career progression
Perception of self as a teacher
Early experiences with the subject
Enjoyment (or not) of teaching biology
Unpleasant aspects of Biology
Personal preferences in the subject
Personal skills
Strategic choice of teaching
Inspiration point
Prior knowledge of the profession
Personal subject limitations
Role of practical work
Lack of relevance in the subject
Range and content of the curriculum
Strategic approach to teaching
Why pupils choose to do biology at A level
Tension between versatility and expertise as a science teacher
Biology compared to other science subjects
Importance of connecting concepts
Pupils' perceptions of biology
Making sense of the subject
Frustration with oversimplifications
Concerns over over-teaching
Barriers to enrichment
Pupils as strategic learners
Thinking scientifically (concerns with / influence of Required Practicals)
Performativity and scrutiny
Importance of biology education
Contemporary issues
Changes to the subject
Lack of status compared to other sciences
Difficult concepts at the higher levels
Underpinning chemistry
Improving pupil life chances as a motivation
Feeling trapped in the subject
Take the emotion out of teaching
Issues with the compulsory nature of science at GCSE
Teaching for understanding
Awareness of personal contradictions
Pedagogical conflict - 'good' versus 'strategic'
Agency of choices (or not)
Rewards of being a teacher
Learning outside the classroom
Broad range of skills needed for success in the subject

Own enjoyment of specific areas influences teaching
Relevance of biology for pupils
Lack of time
Freedom to experiment with pedagogy
Limitations of school context - financial, falling roll numbers
Having responsibility and influence in the school
Seeing things from pupils' perspective
Teaching the 'younger me'
Status of the school (where participant changed schools)
Importance of application of key concepts
Personal learning preferences
Status of the subject within the school curriculum

Open codes for Interview 3

Having control
External guidelines
Wider role of teacher in society
Ethos of school rather than subject
Relating content to pupils
Challenge of abstract concepts
Vocabulary as a barrier
Interaction with pupils shapes pedagogy
Inspirational colleagues shape pedagogy
Colleague expertise and collaboration
Innovative approaches to memorising
Responsibility
Exam success
Challenges that reforms bring
Growing confidence in subject
Awareness of misconceptions
Familiarity with assessment procedures
Strategic teaching
Personal knowledge improves
Identify gaps in own knowledge
Areas of content still a challenge for the teacher
Pupil engagement
Biology as an engaging subject
Constraints of the curriculum
Personal subject likes and dislikes
Status of biology as a subject compared to other sciences
New content is challenging
Mathematical content and status

Appendix 5a: Matrices of responses against images and key questions

Table A5a.1 Photo elicitation introduction matrix

Participant	A	B	C	D	E
How do you feel that this represents what is important to you about biology teaching?	Finding images that 'sum up' the job.				They all link into the same idea that biology is about teaching about the life around pupils.
Image 1	Modelling complex / abstract concepts. [Concepts can be repetitive and don't necessarily get more complex.]	Vocabulary and technical language as a barrier in biology.	(An exam paper) Teaching the content is important because they need to succeed at exams [this can limit your ability to 'enrich' the content]	(Dissection of a rabbit) Pupils' perception of biology is about dissection. Curiosity and investigation. Ethics and thinking about being a scientist.	(Bearded dragon) Getting one to live in the classroom. Bringing biology 'alive'. Getting pupils to recognise the world around them. Giving pupils responsibility for caring for a creature.
Image 2	The image (a human heart diagram) represents the stimulus for becoming a biology teacher. Physiology. Real world incident. [Don't see the point in dissection. Not confident]	Dissection as a way of engaging pupils although not always easy to understand.	(Petri dishes with microbes) Practical in biology can be unpredictable and give ambiguous results.	The importance of collaboration with other science teachers, scientists and among pupils. Keeping up to date with ideas for lessons.	Biology is linked to everything about their lives. Health and physiology. Limited awareness of pupils about the world - important to get across the need to look after yourself and the planet. [Biology as a holistic subject]
Image 3	(Molecular diagram) Importance of biology in terms of health education	(Images / diagrams on display) Cells as an underpinning concept. Misconceptions. Use of visual material and displays to reinforce ideas. Modelling complex concepts.	(Image of a pond with different organisms) Modelling environmental work in the classroom.	(Collaborative project across the country) Involving pupils in 'proper' research. Investigation and not knowing the answer. Relates to an issue in the news. Collaboration again.	(Plants) Trying to make pupils aware of the world around them. Plants in the classroom bringing this 'to life'.

Image 4	(A diagram) Importance of visual representation and modelling. Facilitating exam success.	Modelling an environmental sampling activity in the classroom. Modelling techniques. Trying to do 'practical' activities. [Creative approaches to teaching]	Microscopes are engaging and interesting. Keeping up to date with ideas for lessons.	Trips. Learning outside the classroom. Ensuring that pupils find science engaging and fun. Too much emphasis on exam preparation. Limited opportunities for pupils in the region without this. Better than a picture on a whiteboard.	(Heart dissection) The importance of inquiry and curiosity. Trying to encourage this approach with pupils. Collaboration within the class. Importance of practical work.
Image 5	(Textbook page) The importance of Chemistry to understanding biological ideas. [Keeping up to date with information]	(An image of stationery, pens etc.) How other science specialists perceive biology, the stereotype of colouring things in.	(Image of a camel and a cactus in a pot) Making it 'real'. Using images of or samples of real biological material.	Modelling the technique of quadrat sampling in the classroom. Showing pupils that techniques can be applied to many situations [application of knowledge].	
Image 6	Importance of wider reading [for staff and A level pupils]. Role outside the classroom in writing articles. Collaboration. CPD.	(A 'bored' pupil and a diagram of plant responses) Pupil and personal perception of plant biology as uninteresting and irrelevant. [Relevance to pupils' lives]		Applying the techniques out in the field. Importance of field trips, getting out into the world. Fun and more powerful than pictures. [Creative activities do teach concepts]	
Image 7	Using new technologies to assess pupil understanding quickly.				
Image 8	Example of peer assessment in action. Exam questions. [Recognition of the importance of AfL and feedback as important for 'good teaching']				
Image 9	(A cake made by a pupil that shows anatomy). Importance of engaging pupils. Thinking about creative ways to assess progress and understanding.				

Image 10	(Screen shot of a PowerPoint) Getting the 'content' across quickly.				

Table A5a.2 Responses against key questions in Interview 2

Participant	A	B	C	D	E
Why biology teaching is important (not a specific question but mentioned by all participants)	A: There's, there's the obvious ones but then there are a lot of … so many similarities in areas that you wouldn't think about. Public health, erm … and all these ideas of British values. An awful lot of British values are tied in with how we live healthy lives. P: Hmm A: which is a strong facet of biology A: Yeah, I don't think that they're appreciating it for what it is, because very few of them want to do Biology, in terms of 'I want to be a Biologist' A: and your GCSEs do matter but only to get you to the next stage P: Hmm A: I'm somebody who facilitates a student who wants to do it going from here to there P: Hmm A: and if the student doesn't want to do it then they go from A to, sort of,	B: how it all works I think that's why biology is so important because, I mean yeah, I had a year 7 the other day who wanted to know why they had to learn about sexual reproduction and I just said, you know, are you planning on having children? P: Yeah B: there you go, that's why you need to know about it	C: some of the topics that we do seem very backwards to me, like I think there's so many opportunities, like I love new biology P: Hmm C: Like I, I like listening to podcast broadcasts, like all the time, I'm, like, obsessed with nutrition P: Yeah C: and like, what are the new … and like, the fact that we still, still in Kaboodle the food triangle has got the biggest section is carbohydrates P: yeah C: and all science, every science that you read now realises that that is nonsense P: yeah C: we're eating too many carbohydrates, that's why we've got so many issues C: like, and there's so, I think there's so much more opportunity, so much more scope to model and analyse everything. Let's talk about the modern issues, let's about, actually, that Biology is going to change a lot in the next few years, and actually can we make it more relatable to the	D: Doing it the right way, as they would do in a university or in a lab or anything like that, so just showing the method of how to do it and again it's that sequence of steps, of doing it the right way and teaching them about why … the ethics behind it, why is it important P: Excellent D: to do it like that, and why it's necessary to be ethical with the animals you treat D: This is about having fun but more about use … applying their knowledge P: Yeah D: In, in the real world and I've mentioned it a few times, doing the step-by-step processes that they've learned to get a result or to get data or to learn something new and actually you say yeah, stand on a beach, get a tape measure put it across the beach then every step you put a quadrat down and count what's in it … but actually to do it	E: Right, well they all kind of link into the same, the same idea … I think that teaching biology is just about teaching the life around the kids E: and I think that's really important for them to know what's … what's on their doorstep P: Yeah E: but what's working for … how they work, their bodies, their fitness, their health, all those things that are kind of linked into it, it's just … it's very difficult to sum up P: No, I get that … so it's the idea that you almost just take for granted … part of the scenery or part of yourself but actually it's about understanding that perhaps? E: Yeah, and how things work, in sort of the bigger scale of things E: the other side of the world and how it all kind of works together, and how we need to look after things P: Yeah, and sort of giving that really big perspective as well? E: Hmm. Yeah, and the fact that the forests are being cut

	A and a half P: Hmm A: not quite a B because they don't, they don't want to do that full journey A: but I mean just simply things like understanding the menstrual cycle P: yeah A: how many teenage pregnancies might that save		students? Can we design these experiments, can we design the practicals that are a lot more what the students care about, and they C: Yeah, which is like, on the specification it's like 0.5 hours, like, half an hour on antibiotic resistance P: Yeah C: and it's like, no … I want to do three hours on it P: (Laughs) yeah C: and get them really into it, and understand what, what are scientists going to do next? That's what I think is what we should be doing P: yeah C: is teaching them that actually, yeah, this is the problem going on well, how are we going to fix the Zica virus? How are we going to fix antibiotic resistance?		down and why that's important and all those sorts of things that they see as P: Yeah E: being a bit too far away P: Yeah E: It's not, it doesn't impact them so it's not important P: Yeah. So that idea of connectedness is quite important? E: Yeah.
In the first set of interviews comments were made about the 'status' of biology. Have you any thoughts on this?	A: I don't think that biology is held up with the same status as chemistry and physics. Physics is seen as the most difficult P: Hmm A: followed by chemistry and I think therefore because it's the most difficult it's given the, the sort of premium status but I don't know why	B: and colouring in and … there is this, yeah there's this stereotype of this is what biology is and I like to, you know again talking about cells, getting them to make large cells and doing something like that but I think that the difficulty erm … of biology is quite often kind of underplayed by other people, other scientists who do think	P: No, it's interesting and I certainly know if you've done the IoP stuff they, they're hot on that aren't they? That underpinning C: Underpinning P: stuff C: those models … and yeah … P: There isn't, again from my perspective, there doesn't seem to be much similar for biology	D: I'd argue with them … vehemently … because actually if you look at the amount of stuff P: Hmm D: I mean at KS3, for example, the KS3 scheme of work, there's one page of physics, one page of chemistry and 3 pages of biology P: Hmm D: so actually, the volume of things P: Right D: that we have to teach in biology	

	because it's only difficult in so much as there's a degree of maths to it **A: able to, to … and that's really what any good teacher does regardless of their subject isn't it? That they're able to use multiple skills to be able to put a point across. And also, I think we're seen as the easy science probably because historically it was done by, and this sounds dreadfully sexist and I hate this, but it was done by girls** **P: Hmm** **A: and considered therefore, the easier of the options. Whereas actually I think it's one of the hardest or the hardest actually in terms of the A' level because for GCSE it's so underwhelming in terms of how it prepares our students** **P: Hmm** **A: that they like biology at GCSE** **P: Yeah** **A: they can do biology at GCSE because it, it's pretty easy and then the jump into A' level requires actually a working knowledge of chemistry as well as what you think of**	**of it as a bit of a soft option** **P: Yeah** **B: almost and do just perceive it to be lots of colouring in and nice pretty pictures and** **P: yeah** **B: things like that** **P: something that a physicist said to me a couple of years ago, I was interviewing them, and they said 'oh, I hated biology, because you didn't need to understand anything, you just had to learn it' and I thought, right okay, that's not true but interesting** **B: Yeah, so I do think there is this kind of perception that of the three it's the weak option it's that it's the easy option and you know, obviously that's not the case** **P: That's fine. Erm … one of the questions I've got for everybody, and it was actually you that brought it up, you said about the status of Biology as a subject with other science teachers and that you felt erm … it was wrongly given the status of the easy option** **B: Yeah** **P: How's … how has that impacted on you as a biology teacher do you think?** **B: Erm … I do think, you know I do think even amongst the**		**makes it harder** **P: Yeah** **D: and the words that we have to use** **P: Yep** **D: the precision of the words** **P: Yes** **D: and the concepts we have to use makes it harder** **P: Yeah** **D: but I think, and I think it makes it … conceptually I think it's quite hard as well** **D: I guess something else that stood out that I thought was quite interesting was erm … other people's views on biology** **P: Hmm** **D: other science teachers** **P: Yeah** **D: views on biology and I think it's kind of what you … again what you linked on to that it's less of** **P: Hmm** **D: the sciences** **P: Yeah** **D: there's kind of a stereotype to it** **P: Yeah** **D: and I get it … I got it coming here actually, we interviewed someone, and I said, oh, I'm the biology teacher and he … oh, cutting and sticking … no … not in my lessons, I don't think I've ever cut and stick** **D: in my lessons actually and I kind of was offended by that or one … one person in my training school erm …said, oh biology, that's**	

	as biology and a reasonable knowledge of physics by **A: ridiculously hard, especially if you've got a child who isn't a scientist, who's gone 'right I'm going to do, I'm going to do art, I'm going to do French, I'm going to do English Language and I'm going to do, I'm going to take Biology because I want to do a Science, I want to keep my options open'** **P: Yeah** **A: so, they, they do that. They would pick biology they wouldn't pick chemistry or physics because the chemists and physicists are the youngsters who, who are good at maths, who are good at physics, who want to carry on being good at maths and physics**	**kids you do get quite a lot who go 'Oh I like Biology, Biology's easy'**		**women in wellies, isn't it? So, I think that that, I'd never come across that before** **P: No** **D: because I'd been with biology people and been with A level biologists and done my degree in it so** **P: Yeah** **D: we always thought … biology's really good**	

Table A5a.3 Responses against key questions in Interview 3

Participant	A	B	C	D	E
What do you feel is currently influencing the way you approach biology teaching?	A: so, I … it seems like I'm actually using my degree for a while. Er … in terms of … in terms of how it's examined … your guess is as good as mine, I think. That changes every 5 years A: So, I don't think, I don't think that'll change. It'll be interesting to see how we teach evolution over the next few years P: Hmm mm A: because of … when … if we continue to go with our current wave of populist … er … politics … there's a definite shift in terms of … already … in terms of how you teach, perhaps, contraception, vaccination A: But then vaccination seems to be now this thing that we're … P: A bit more careful about A: A bit more careful about because you … P: That's interesting, right, yeah, yeah A: and I don't think that's so much led by the faith it's just that the idea that popular P: Society A: society is, you know … A: Yes, and the other	B: I think quite a lot of it is just trying to relate it as much as possible to context, or trying to, you know, give them something physically to look at. So, I know erm … originally, I was saying that there are somethings that are quite complicated because they're very uh … abstract B: that has affected it slightly. Erm … I mean H**** who is the former head of department was a fantastic biology teacher, she was a … erm … had a really great bank of resources lots of er … lots of different things like that which I use quite a lot and er …we've been doing quite a lot of sharing ideas, it seems quite a lot of me sharing suggestions for P: Hmm B: practicals at the moment with the new scheme of work B: No, no it's a revision technique P: Oh, I see, sorry I am mixing it up with … a different … B: Yeah P: colleague's doing that B: No, it's the one where you have a kind of really intense PowerPoint P: Oh right B: and then you stop, and they all move away and they, like, we've got loads of juggling balls in a bag which	C: Erm … I think it's one of those things where because I'm doing so much of the getting ready for Mastery and I'm teaching a lot of lessons that are going to be used next year er, and also the fact that erm … also the fact that I've now got the group of year 12s this year that got good GCSE results but like, it's … you … stand at the front sometimes when you're talking about things and it's like … how did you even get that good P: Yeah C: GCSE grade and the thing was erm … what at the minute's probably influencing me is the way in teachers … I've really started to understand that … that without those underlying stories and principles … if they're not in your brain … even if you don't remember it, you can still understand it C: and I think doing what I've been doing with Mastery and the courses that I've been doing it's … I'm really starting to understand it. A student can work out an answer if they've got core principles that they understand P: Yeah C: so … that … a cell is a cell and particles will move in and out of it. That's something that you can know and if you say that that's diffusion but just the fact that you und … that	D: Hmm … I guess erm … what I kind of think is that changes that are happening in education P: Yeah D: but not just that but … I think the changes that are happening within science P: Hmm mm D: I guess, you know the erm … new advancements, I guess and two parts … I think, I think with erm … I'm quite big on Twitter so I always use Twitter to follow the new techniques and I think teachers are sharing ideas more about teaching and learning but I think back in the past you'd get one really good research idea, and everyone would all jump on board and kind of do the same thing D: like that. Where actually now if I go on social media and interact with other teachers there's more sharing across the country P: That's good D: so actually, one of the main things that's changing my teaching is looking at new ideas that other people are doing randomly D: so, I think that one thing that's changing is teachers sharing their ideas P: So, you've almost got this virtual community D: Yeah P: which you didn't have D: it's like, essentially, it's like a huge Teach Meet, what was a Teach Meet	E: To be honest at the minute it's the exams P: Yeah E: It's all that prep for, especially this year, the unknown of … P: Yeah E: what was going to be in there? P: with all the changes and things E: particularly the practical type stuff and how that was going to be assessed and P: Yeah E: how, 'cos our kids in particular, I'm assuming that it's quite a broad thing, but they struggle with the practical skills when

	aspect there is of course diet because … P: Yeah A: certainly, when I trained er … you didn't have high fat whereas now what we're saying is it's probably not the fat it's the sugar P: Hmm A: that's maybe the issue. Er … you know, we seem to have gone through a whole shift of our understanding about salt and vitamin C and vitamin P: Yeah A: D and so they're, they're interesting subtle, little changes	were given to us by the 'Spaced Learning' project P: Oh right B: so, they go away and do something entirely different and then come back and for the first time they just listen and then second time around they can shout P: Right B: out more answers P: Oh, I see B: and as a revision technique it works really well.	concept they can then use and apply to lots of other different situations C: Because they haven't got there themselves. So, I'm sort of trying to flip my teaching a little bit doing the apply, not necessarily first but giving them opportunity to try and break the misconceptions, work out their own misconceptions P: Hmm C: in their heads and have these, like rules, principal rules that they can stick to and keep applying P: Hmm C: and then teach them content after C: And it's one of those things, isn't it? Where it's like … it's like I've done quite a lot of fun things with my A level groups and this and that, but they didn't get very good mock results P: Hmm C: and when the new head of biology is like hmm with these lot's marks, the conversation wasn't 'but actually it's really good that you've done this with them and they said that you'd done this' it was that they didn't get very good marks, what happened? What did you do? What should we do next? P: Hmm C: and the conversation is constant … the conversation is always about what result this kid is going to get		
What experiences		B: I think erm … obviously I think getting more familiar		D: Erm … I think … more time to look … to get ideas from other	E: Erm … PGCE I did a bit of A level, I did top sets, bottom

have or would have been helpful as a beginning teacher?		**with the spec would have been really useful from the very** **P: Right** **B: early start. So, having more knowledge of the kind of exam questions and things like that would** **P: Hmm** **B: be taught, and I think erm … having that bank of practicals because sometimes it's not always really obvious where you can get something in** **B: so, having that kind of experience, more experienced colleagues to suggest ways of modelling something, things like that so having that bank of resources I think** **P: So not necessarily full-blown experiments but** **B: No but little, yeah, little kind of modelling techniques** **P: Yeah** **B: and things like that erm … I also think that, yes, kind of, as the experience comes, things like revision techniques** **B: and now, you know with experience, I'm aware that that's a dreadful way of revising and having more of those kind of tools to actually help** **P: So?** **B: when it comes to the most, kind of, important part really which is** **P: Yeah** **B: the exams**		**people** **P: Hmm** **D: or a specific, maybe, I thought … me and a colleague talked about this actually, what would have been useful, and we thought that one of the most useful assignments we had in our PGCE was the research one, you know?** **P: Yeah** **D: the research, so you'd pick an idea, you'd get** **P: Try … try it out** **D: We thought that was the most useful one maybe a specific task to do, so my school when I trained made us deliver that in like our training session** **P: Right** **D: so, our … what we found in a training session, so I think student teachers or someone starting out in teaching should be given tasks to do that actively makes them … find new ideas in teaching**	**sets, I covered** **P: Yeah** **E: quite a lot of** **P: Maybe it's dependent on where you get placed** **E: Yeah** **P: perhaps as to …** **E: Nothing that's particularly struck me at any point**

Do you have any thoughts on the biology teacher you want to be in the future?	**A: No. The genetics side of it … epigenetics is becoming more and more interesting** **P: Hmmm** **A: to the point where, perhaps in 20 years' time, if I'm still at it (laughs) I might have to do a bit more reading** **P: Yeah** **A: Er … but at the moment I don't think it's impacting that much on my subject knowledge** **A: over an average 30-year career that things do change (unintelligible) I think, me personally, I've decided that I'd like to be a boss. I'm 36 so by the time I'm 40 I want to be the boss** **P: Right, okay. Like the big boss?** **A: Well … not the big, big boss but** **P: Like, part of that team** **A: Yeah, head of department, SLT** **A: but at the same time … actually … having had children … who have grown up and now started school in the course of your project** **P: Hmm** **A: you see a comp … you see a completely different side to schools** **P: Hmm** **A: things that you didn't see as just a teacher** **P: Hmm** **A: and, you know, you see your wider role in**	**B: that kind of idea. Erm … I've also kind of learned to not go into too much detail so when they start talking about green eyes, I'm just like … no, no there's no such thing. So, I try … I know more likely what's going to come up on the exam so try not to get too** **P: Yeah, yeah** **B: too side-tracked** **P: Yeah** **B: with added detail that they don't need to know, I'd say is something that I'm more conscious of now whereas before it would be a case of ooh, we haven't got time to finish the course because I've spoken about all this stuff that you're never going to actually get**	**C: I think … it's one of those things that's more logistical than anything** **P: Hmm** **C: I still feel like I just haven't got enough time to do everything** **P: Hmm** **C: Like … there's so many … I'll come in on, like, a Monday and I've got a lesson period 3, and like, I haven't planned anything, and I haven't got time and it's just … there's so much more I want to do and so much I want to expand, like, my resources and how I teach** **C: and … but it's not like it's … it's just time management and, and I think as well just making sure that my resources are in the right place were** **P: Yeah** **C: that I could just teach it if I need to** **C: what's the first thing on Bloom's? It's, be able to state something** **P: Hmm** **C: and I …I remember teaching in that order** **P: and in a way it's because it's the easiest** **C: Yeah** **P: and the least relevant and … yeah …I've seen quite a few Bloom's where it's flipped now** **C: so like, now, my aim, every single time is … from do an equation … I say to myself you've got to do a practical beforehand** **P: Yeah** **C: Not a … you're not allowed to show them the equation**	**D: I just think keep being willing to learn new things** **P: Hmm** **D: and try new things and try not and settle** **P: Hmm** **D: 'cos when you think you've got it and you're kind of, oh, I'm quite good now** **P: Yeah** **D: then you can't … you** **P: you get out of date and** **D: become complacent** **P: immediately, don't you?** **D: Yeah. But it is … and then going back to my original theme it is keeping on top of all the changes** **P: Yeah** **D: every little change that could happen, not just … the major curriculum ones** **P: Yeah** **D: so, I actively now, in my lessons, thinking of … and then it goes back to my original point, new things in science or any biology that's happened and trying to apply it to a topic that we're teaching** **P: Hmm** **D: so that they have to think how does this relate?** **P: So, it almost doesn't matter what the context is, if you understand it?**	**E: I think I still want to be that biology teacher that at least, even if it's just one, she did, you know she did some really good lessons and as a result I want to be in the science field.** **P: So, inspiring someone to …** **E: Yeah, because I remember that, it, for me it was my physics teacher, so he's probably annoyed that I did biology (both laugh) but it … that I think that's quite powerful, the fact that you can influence …** **P: Yeah, and it's back to … quite a few people have said it's about engaging pupils isn't it** **E: Yeah** **P: and, and passing on that, almost that love of your subject** **E: Yeah, getting them interested, getting them asking questions, making them want to go further and ask, you know asking questions that I can't answer, I don't know the answers to all of these**

	society **P: Yeah** **A: and I see it in my children … the teachers … so yeah, being … having that bit more responsibility over the actual way you impact on the ethos of the school, as opposed perhaps to those 200 children that you** **P: Hmm** **A: are responsible for that year … is a …bigger thing**		**until they've seen a practical that shows …**		
Impact of the introduction of Required Practical work. [Depending on the time of the interview]	**A: No, I don't, I don't think it has in terms of their practical skill. I think it's actually taken it the other way. I think, I think we now have students who, who … can't understand or don't want to understand that a practical will occasionally not work for various reasons** **P: Ah yes** **A: and actually, what they're now doing is saying well … I need to know the answer to this practical for my exam whereas actually you don't, you need to learn the process** **A: they're fixated on the result of the practical and the ability to draw a nice graph rather than …** **P: It being a science process** **A: actually, looking at the control and the kind of variables and the process. The scientific**			**D: No. Just when you read my summary out, I think when I talked about the Required Practicals … I think that's quite a negative thought and I do** **P: and they hadn't started, had they? I was going to say …** **D: No, they hadn't and now I've had a year doing them** **P: Oh yeah that's** **D: and they've never been as bad or as restrictive as I've thought** **P: Good** **D: So, I think, I think that is actually kind of a way forward I get the idea, where it's coming from. The idea that they all have to do these Required Practicals** **D: and can introduce your own way of teaching their skills** **P: Yeah, making them engaging and I know I only pulled out that concern, but you did, we did talk about the fact that … or it could be a good way forwards so** **D: Yeah, and it turns out I think it has been a great way forward**	**P: So not remembering a recipe** **E: Yeah, sort of developing that ability to look at something and thinking right, well this is how I'd approach this task rather than** **P: Yeah** **E: I've been given this, this is what I do with it** **P: Yeah, and I suppose that … it disappeared, didn't it? So yeah, it's not just …** **E: Yeah** **P: your pupils, is it? There will be lots of pupils who haven't really … haven't really engaged with that sort of stuff** **E: Yeah, it's quite a …** **P: Does your kind of, your approach to it being perhaps a little bit … a little bit more about problem solving and collaboration has that helped at all do you think?** **E: I think it has, yeah. I think it has because that gives them that, sort of, expectation that they need to work something out**

	question that they're asking				

Appendix 5b: Personal Stories

Personal story 2:

As I have said before I was really, really interested in science as a little kid. I read lots of books and had a real passion for natural history so one of the things I was really looking forward to about secondary school was proper science lessons with experiments and everything. I remember vividly one of my first lessons on a topic about the nature of matter, so atoms and molecules, that kind of thing. This was complicated, grown-up science. In preparation for this I had taken a couple of books out of the local library about atoms and molecules. So, in one of the lessons the teacher explained that no-one could see atoms or molecules, there were no pictures of them, remember this was the early 1970s. However, in one of my books there was an image of a molecule. I now realise that this must have been an early image of X ray crystallography on a macro molecule, perhaps DNA. I brought the book in and after the lesson I wanted to ask the teacher about it. What was I looking at? How did the image get taken? How can you see a picture of some molecules? I don't know, lots of annoying questions I suspect. Anyway, this teacher simply shut the questions down. No attempt to answer or even fake an interest. I was simply slightly told off for waiting behind and sent away. As you can see, I still remember it, and vowed never, ever to behave like that to any pupil, ever!

Personal Story 3:

I must have been, either in the equivalent of the NQT year or maybe in my second year of teaching and the National Oracy Project was happening with some key people involved being based in Wiltshire. They were interested in getting teachers from subjects such as Maths and Science involved in the project and I just remember being intrigued by the idea of pupil talk as a way of facilitating understanding – I think I still say to students that a really good way to understand what a pupil is thinking about something, what understanding they have of a concept is to get them to talk about it, preferably without using technical terms. There is something about that translation. Anyway, I volunteered to be involved and this meant that I worked with a couple of absolute experts in the pedagogy of structured small group oral work and later on in 'writing to think,' which was an associated project, I think. The support involved someone being in my classroom and working alongside me, so I would teach the science aspects, perhaps explain an episode of practical work and then they would do the structured group talk with the class to model it. I can't remember how long this was but as we progressed it became about co-planning lessons and then about me taking control and organising the talk or the writing. What I do remember is how fascinating I found the whole process and I guess it was this that started me thinking about the underlying theory of how pupils learn in science. I remember being encouraged to write up small pieces of action research for the Oracy magazine, I had a lesson videoed that I think was used in some training and I was asked to run part of a CPD day in my school. I remember that this was incredibly exciting stuff, totally empowering because I hadn't been teaching for very long, but I was beginning to get a reputation as the person who was innovative and creative in terms of science teaching in the school. That early intervention, support, whatever it was, proved to be very powerful in terms of the way I saw myself as a

teacher and I always consider it as being the first step on my journey to becoming a teacher educator.

Appendix 6 Selective codes and categories

Table A6.1 showing selective codes generated from the initial list of open codes and categories generated from selective codes

Analytic codes	Selective codes	Categories
Interview 1		
Abstract, complex concepts Vocabulary as a barrier Relevance to pupils Need to connect concepts Underpinning chemistry	The range and content of the biology curriculum	**Dealing with a complex and challenging subject**
Modelling difficult concepts Role of technology Pupil engagement	Pedagogical approaches	**Teaching for understanding**
Role of practical work Investigative / problem solving approaches Role of dissection	Practical work in biology	**Experiencing practical work**
Assessing pupils' understanding External notions of 'good' teaching Exam success	Accountability	**Working within an accountability framework**
Strategic decision Impact of an inspirational person or event Family members in the profession	The route into teaching	**Becoming a biology teacher**
Role of collaborative work Physics CPD Wider science expertise	Developing as a teacher	**Developing as a biology teacher**
Status compared to other sciences	Others' perceptions of biology	**Being aware of how others perceive the subject**
Health education Awareness of the natural world Contemporary issues	Importance of the subject in school	**Arguing the role of biology as a subject in school**
Interview 2		
'Failed' initial choices Necessary grades Inspirational incident or person Strategic choice Prior knowledge of the profession	The route into teaching	**Becoming a biology teacher**

Aspects not liked Personal interests Complexity Time and barriers to in-depth knowledge Range of content Relevance to pupils lack of contemporary issues Need to connect across 'topics' Underpinning chemistry	The range and content of the biology curriculum	**Dealing with a complex and challenging subject**
Why pupils choose to study it Status compared to other sciences Status of science in school Pupils' perceptions of	Others' perceptions of biology	**Being aware of how others perceive the subject**
Not a specialist Improving pupils' life chances Personal contradictions Agency or lack of Status and responsibility Trapped / reluctant Conflicted Personal enthusiasm Physics CPD	Perception of self as a teacher	**Growing personal professional insight**
Strategic teaching Connecting concepts Barriers to exploration Making sense of the subject From the pupils' perspective Teaching the 'younger me' Conflict – 'Good' teaching versus strategic teaching Freedom to develop Responsibility and influence Status of the school Personal learning preferences Practical work	Pedagogical approaches and barriers	**Feeling of pedagogical agency within the school**
Career progression Barriers to development in the classroom Influence of curriculum reform Exam success Conflict over pedagogical approaches	Accountability / scrutiny / performativity	**Feeling of pedagogical agency within the school**

Status Value of CPD Responsibility A level provision Time Creative approaches	The school context	**Feeling of pedagogical agency within the school**
Interview 3		
External demands of the curriculum External assessment procedures Interaction with pupils Growing personal confidence School context Responsibility – explicit recognition of expertise Sense of agency in the classroom Growing personal insight	Factors influencing pedagogical decisions	**Factors influencing pedagogical decisions**
Interaction with knowledgeable others CPD Collaboration Sharing practice through social media Willingness to develop Critical approach to pedagogy Impact of colleagues		**Interaction with knowledgeable others**
Difficult concepts School curriculum very broad Challenging technical vocabulary Misconceptions The 'forgotten core subject' Pupil engagement Contemporary issues not represented	Challenges of the subject in secondary school	**Dealing with a complex and challenging subject**
Growth of personal subject knowledge Awareness of lack of understanding at pre-service stage Ability to link educational theory Wider role of the teacher	Perception of self as a teacher	**Growing personal professional insight**
Interaction with pupils Relevance to pupils Self as a pupil Personal likes and dislikes in the subject	Growing awareness of own pupils	**Reflection on own experiences as a pupil**

Performance of the pupils under scrutiny 'Status' of the school Time available in the scheme of work Access to formal CPD Own expertise is recognised in the school	The school context	**Receiving explicit recognition of expertise**
Importance of teaching for understanding Investigative approaches important Application of key principles in science Societal concerns reflected in scheme of work – problems with this	Teaching for understanding	**Teaching for understanding**

Appendix 7: Example of a memo

Memo: An interesting theme emerging around subject pedagogical power.

School context seems to play a key role in this but there are also some 'self-imposed'? constraints that appear to come from custom and practice.
Find literature on 'norm practice' / neoliberal schools that I was looking at

Where people feel that they have it:

P: So yeah, indoor quadrating, yeah
B: Indoor quadrats, indoor transects anything just to try and again, make it more visual, make it something they can get involved with to try and help embed it somehow
P: So, you've got actually, quite a nice big classroom
B: Yeah, it's really big so I can just push all the tables to one side err … irritate the cleaners by scattering paper all over the place and I did have some lovely daisies that I cut out and I lent them to another teacher

P: What's it like at Key Stage 3 then? Are you fitting stuff in or again is that a rush to get that foundation content?
C: For me I think we've got a really good scheme of work we do 'Activate' and they have a practical every single, in every single lesson

C: Yeah, we haven't been limited in any way and we have a good, erm … supply of stuff like that. But it were this class in particular, that's -------- there he's actually trying to find the genitalia

D: The school are very good because they, kind of, let me do what I want. So, I've never had any … I've never had any barriers to what I want to teach

Perceived external constraints:

A: and so, we were basically looking at what's good, what could be improved and the whole class contributed to improving this guy's work here and he was given a fresh copy and he wrote, potentially his own version of a model answer. So, it had all the, the sort of feed forward, feed back
P: Yeah
A: everything with bells on really that it needed to do.

A: Yeah, also that would be completely an anathema to many of the current, I don't know, awarding bodies. They wouldn't think to, to reward creativity in that way.

A: as much as you can. I don't think I try to do it all, but I'd like to, but I don't think I try because I think you … we're constrained by the course
P: Hmm

A: and we're constrained by the fact that we have a generation of young, youngsters, but certainly in this school, who want to know the course and nothing but the course and it's just
A: because the EBac, especially schools like ours because … the EBac is all consuming … and I think you're also tied in with the special, the specialities of your teachers, I mean, that idea, perhaps that idea of needing a trade and technology that we used to have, I'm certain it died off when I was a kid but

B: to get through and I think with the new spec it's far less easy to go off on a tangent
P: Yeah
B: and kind of, explore that stuff
P: Yeah
B: with the, I mean, with the year elevens who've just left I felt very free to do what I wanted with them, but I think with the new spec, either it's a case of 'cause they're not entirely sure what's going to be examined or, or what the kind of, the exam's going to look like

B: you know, a big discussion and I'll just see what you find, because it's being documented and because they've got to show that they've got all of these various skills so that then all of the practicals are very regimented