Supporting the development of preservice science teachers' reflectivity using action learning and the diagnostic teaching cycle: A case study

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Abstract

This study concerns the development of science preservice teachers (PSTs) on a university-schools partnership Postgraduate Certificate in Education (PGCE) course in England. The topic is of interest owing to the shortage of science teachers, and a concern that science PSTs progress less well on the course than PSTs of other specialisms. This work details a case study of an intervention undertaken with PSTs during the course, on which I was a tutor. Prior research suggests that science teachers are not very reflective, and I hypothesised that this lack of reflectivity may account for their difficulty on a course which adopts a *reflective practitioner* model. The whole group of 38 science PSTs took part in an intervention designed to support development of reflection, of whom eight volunteered to participate in the research. Seminars about two key elements of the intervention, the *diagnostic teaching cycle* and *action learning (AL)*, took place in the university setting at four points between October 2016 and April 2017. Data collected include audio recordings of AL sets; written reflective journals, analyses of critical incidents, and action plans; and school mentors' reviews and reports of participants' teaching. I investigated participants' reflectivity using Zwozdiak-Myers' *nine dimensions of reflective practice*. Participants' reflectivity varied, but this was not necessarily related to course completion, nor to the final grade awarded for their teaching. Linking theory with practice emerged from the analysis as a weakness. I carried out a thematic analysis of teaching issues raised by participants. Classroom and behaviour management was their predominant concern – perhaps due to a difficulty in establishing appropriate working relationships with pupils. In my evaluation, evidence supports retaining AL in the PGCE, particularly given the benefits of peer support. However, a weakness was that participants did not question their assumptions, including those related to pupils' abilities.

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Glossary

AfL	Assessment for learning
AL	Action learning
AY	Academic year
BERA	British Educational Research Association
CBM	Classroom and behaviour management
DES	Department of Education and Science
DfE	Department for Education
Ed.D.	Doctorate in Education
DTC	Diagnostic Teaching Cycle
ITE	Initial teacher education
NASBTT	National Association of School-Based Teacher Trainers
NOS	Nature of Science
NQT	Newly qualified teacher
Ofsted	Office for Standards in Education
PCK	Pedagogical content knowledge
PCM	Professional Coordinating Mentor
PD	Professional Development
PGCE	Postgraduate Certificate in Education
PST	Preservice teacher
RQ	Research question
SQ	Sub-question
TA	Teaching assistant
TS	Teachers' Standard
UCET	Universities Council for the Education of Teachers

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Chapter 1. Introduction

1.1 Motivation for the study

I worked as a physics specialist science teacher in secondary schools in England for 17 years before becoming a Lecturer in Science Education. In my university role, I was a tutor for the physics (and science) specialist preservice teachers (PSTs) on university-schools partnership Postgraduate Certificate in Education (PGCE) courses at three universities. Whilst working in initial teacher education (ITE), I also had a coordinating role on two employment-based modes of training, which were Teach First and School Direct Salaried. At the time of completing the thesis, I am employed as a Participant Development Lead for Teach First, working with trainee teachers and newly qualified teachers (NQTs). I refer to the university at which the research was carried out as Green University throughout.

The inspiration for this study is a practical problem that arose in my professional practice. ITE providers in England commonly record a grade of 'outstanding', 'good', or 'requiring improvement' for each PST at the end of their course. PSTs' teaching practice is assessed against the Teachers' Standards (TS, DfE, 2011, Appendix A). In the period in which the research was carried out, assessment took place with reference to guidance agreed by the National Association of School-Based Teacher Trainers (NASBTT) and the Universities Council for the Education of Teachers (UCET) (UCET & NASBTT, 2012). Generally speaking, I have found physics PSTs' end of course grades to be lower than those for PSTs of other science specialisms, and that science PSTs may attain lower grades than PSTs of other subject specialist backgrounds, such as English or History. Appendix B shows data for Green University aggregated over the three years prior to my research.

Ofsted (2014:12) asked Green University to

> further improve the recruitment and selection process, so that a greater proportion of trainees are recruited with the potential to become outstanding teachers, especially in science and mathematics.

However, there is a difficulty with this suggestion because there is a national shortage of physics teachers (Institute of Physics, 2015) and too few people are coming forward to train (Gatsby Foundation, 2015). Thus, being more selective would be unhelpful, as we would still fail to prepare enough physics teachers to address the shortage.

I suggest that we must rather look at how people who wish to become physics (or science) teachers can be supported during their training, in order that they may be successful. Rather than looking at what their tutor or mentor can do to support them, I developed an interest in helping the students to help themselves.

I considered looking at mentor development, but I think the challenge is too great. This impression from my professional experience is somewhat supported by Cameron's (2014:187) study of mentoring, which suggests that 'mentors in school perceive there to be deficiency of time and resources available for mentoring in schools'. He concludes that 'allocating additional funding to schools for mentoring is probably necessary', as well as recommending wider systemic change, such as sharing best practice in mentoring through Teaching Schools. I am not certain that additional funding will be provided. Despite government assurances that the education budget is increasing, schools report that these increases are not sufficient to cover increasing pupil numbers and increased running costs (Richardson, 2018). Additionally, if I were to succeed in equipping PSTs with a means of developing their own professional practice, then there is the possibility of a longer-term effect on their work, once the support of mentors and tutors has ended.

The employment-based routes into teaching on which I worked, in particular, raised a question for me about how PSTs learn to teach. Generally speaking, the courses on which I have worked appear to be based on a reflective practitioner model. These approaches to reflection have their roots in the work of Dewey (1933) and Schön (1987). My thinking was that reflective practice was more highly developed in the Teach First programme by necessity: Because PSTs spent less time learning about education in the university, and because they were teaching a relatively heavy timetable of science lessons from the beginning of their training year, they needed to be equipped with a method of developing their own teaching more than those on a university-schools partnership course. Reflective practice was supported to an extent through a reflective journal assignment in which PSTs applied a model of reflection to develop aspects of their practice, including classroom and behaviour management (CBM), and assessment for learning (AfL). I became particularly interested in Tripp's model of the diagnostic teaching cycle (DTC, Tripp, 1993), which forms part of the intervention I carried out with PSTs as part of this research project.

The weakness, for me, of the reflective journal assignment was the model of teacher learning that it suggested. It implied that the PST learns by working alone, thinking about their teaching problem in isolation; writing about how to solve it; and carrying out an enquiry in their classroom independently. It seemed to me more likely that PSTs would benefit from talking to one another about their teaching. Indeed, my experience of working on several university-schools partnership PGCE courses suggests that a main strength of some is that PSTs have regular opportunities to come out of school placements, to share their experiences with one another.

Action learning (AL) came to my attention during a secondary PGCE mentoring conference (Bayley, 2015). It was introduced to PSTs at Green University in the following academic year, and a limited pilot took place, focusing on structured peer group discussion of teaching issues in the AL set. I develop the use of AL further in this project, which explores the potential of the DTC and AL to help PSTs solve their teaching challenges during the PGCE.

1.2 Ontological and epistemological stance

In this study I adopt a critical realist perspective. I explore this stance in greater depth in the literature review (2.2). I wish to adopt a position that could apply to both natural sciences and social sciences to bring coherence to my approach.

I have a science background, and work with PSTs, who will teach science to young people. PSTs' epistemological and ontological assumptions are important for two main reasons. Firstly, Osborne and Dillon (2010) suggest that their view of the nature of science (NOS) affects the way in which they teach science. Secondly, Malthouse and Roffey-Barentsen (2014) suggest that science PSTs are not very reflective because they are positivists. For this reason, I elucidate my view of the NOS, as well as the position I adopt within the social sciences.

As I explain further in the literature review (2.2), my view of the NOS is in line with inference to best explanation (Bird, 2006) and perspectival realism (Giere, 2006). These positions appear to overcome concerns about naïve realism or logical positivism because they are critical, in the sense that they are aware of their own limitations.

In the social sciences, I find myself to lean towards interpretivism, as opposed to positivism. However, there may be a third way, distinct from positivism and interpretivism, which is critical realism (Denzin & Lincoln, 2011). Within critical realism, ontological realism, epistemological relativism and judgmental rationality are not seen to be incompatible with one another (Bhaskar, 2017).

1.3 *Prima facie* research questions

At the outset of the project, I was particularly interested in the development of physics PSTs. I wished to gain a better understanding of the difficulties they experience during their PGCE. Hence my first research question (RQ) was:

- What are the barriers that physics PSTs face during their PGCE?

Secondly, I was interested in evaluating the potential of AL as a method of supporting physics PSTs' development, in order to improve their teaching:

- Does AL help physics PSTs to overcome the barriers they face? If so, in what ways? If not, why not?

1.4 Outline of the thesis chapter by chapter

In Chapter 2, *Literature Review,* I explain in greater detail my ontological and epistemological assumptions. I then introduce what we know about ways in which science teaching may need to be developed, including reference to Malthouse and Roffey-Barentsen's (2014) suggestion that they may not be very reflective. I also introduce ideas about science teacher development, including Bell and Gilbert's (1996) model. One condition considered necessary for science teacher development is critical reflection, so I begin to introduce reflective practice. I then describe the theoretical underpinnings of the teaching intervention:

- The DTC (Tripp, 1993)
- AL (Bayley, 2015; Aubusson, Ewing & Hoban, 2009)

I describe the theoretical underpinning of the data analysis. I use Zwozdiak-Myers' nine dimensions of reflective practice (Zwozdiak-Myers, 2012) as an analytical lens through which to view participants' reflectivity. Within this discussion, when considering participants' linking of theory and practice, I use Korthagen and Lagerwerf's model of three levels of teachers' professional learning (Korthagen and Lagerwerf, 2001). The fact that developing CBM was a barrier for participants

emerged from the data. I review ideas as to why this might be. I use Furlong and Maynard's (1995) stage model to analyse participants' development, including their suggestion that PSTs need to develop appropriate working relationships with pupils to develop CBM. I end the chapter by explaining how the RQs were modified in light of carrying out the literature review.

In Chapter 3, *Methodology and Methods of the study,* I introduce the study's methodological framework, explaining how this is compatible with my ontological and epistemological assumptions. This is case study research, where the case is the group of eight research participants, who were science PSTs on the PGCE programme at Green University during the 2016-17 academic year (AY2016-17). I go on to describe the case study's purposes, approaches and processes. The second part of chapter 3 concerns the study's methods. I briefly introduce the context and participants, about which I give greater detail in Chapter 4. I then describe the methods of data collection, which are observational (consisting of audio recordings of AL sets) and documentary (including reviews and reports on PSTs' teaching, as well as reflective journals, critical incident analyses' and action plans). I describe the methods of data analysis, where I have carried out thematic analysis. This chapter includes questions of quality of case study research, where relevant, as well as consideration of my position as insider-researcher. I also discuss ethical considerations.

In Chapter 4, *Context, fieldwork activities, participants and themes,* I first describe the context, fieldwork activities and participants in greater detail. Participants were invited to keep reflective journals, with the intention that they would later create critical incident analyses based on teaching issues that arose. Teaching issues were then discussed in AL sets, after which participants wrote action plans. The intention was that participants would collect data to produce evidence of progress in overcoming their teaching issues. Participants reported back orally in subsequent AL sets, and completed written reviews of their action plans. Several cycles took place during AY2016-17. Secondly, I introduce the main themes identified in the data, which are CBM, reflectivity, science subject-specific difficulties, and participants' progression. I illustrate the themes using examples from the data. Finally, I reflect on the themes, pointing to the material that appears in the data analysis and discussion in chapters 5 to 7.

Chapter 5 *Participants' reflective practice* explores the suggestion that science PSTs may have difficulty in learning to teach because they are not very reflective (Malthouse & Roffey-Barentsen, 2014). I adopt Zwozdiak-Myers' (2012) nine dimensions of reflective practice as an analytical lens. I begin by giving further detail about how I conducted the data analysis. Secondly, it was suggested in the literature that science teachers are wed to transmission modes of teaching. I explore the extent to which this was evident for the participants' teaching with reference to aspects of data for *Dimensions 6 Try out new strategies and ideas*, *7 Maximise the learning potential of all your pupils* and *8 Enhance the quality of your own teaching*. Thirdly, I consider the extent to which participants linked theory with practice since it emerged from the data that participants made little reference to material that was taught on the PGCE course. *Dimension 3 Linking theory with practice* is relevant here. Finally, I consider the extent to which reflectivity was related to participants' course outcomes.

In Chapter 6 *Barriers to participants' development*, I begin by presenting the outcome of a thematic analysis of the data. Emerging from the data was the fact that participants had difficulty in developing their CBM – to an even greater extent than I would have thought based on my previous experiences as a PGCE tutor. Whilst carrying out further reading, I was struck by some similarities with Furlong and Maynard's (1995) model of PSTs' development, which I describe. I suggest that my research participants were comparatively slow to develop. I go on to consider the data in relation to Furlong and Maynard's suggestion that PSTs' difficulty may be in developing appropriate working relationships with pupils, drawing upon additional literature, where applicable.

In Chapter 7 *Evaluative analysis of the teaching intervention,* I evaluate the extent to which the teaching intervention worked to support participants' development. One of my initial interests was whether or not AL should be retained in the PGCE course, and this is considered – together with the question of whether other elements of the teaching intervention should be retained. Aubusson *et al.* (2009) suggest that four learning processes underpinning AL are *reflection*, *community*, *action* and *feedback*. I discuss each of these elements, using examples from the data, to consider the extent to which AL worked in the way that was suggested. In doing so, I consider the views

of the participants, and my own views as course tutor and researcher, comparing my implementation of AL with that in other studies, where relevant.

In Chapter 8 *Conclusions,* I consider what I have learned from carrying out the study. I begin by restating the purpose of the research. I then summarise the answers to the RQs, considering how well they have been answered through the enquiry. I then reflect on theory. Since the study was carried out for the professional doctorate in education (Ed.D.) a key consideration is implications for practice. Policy and practice in ITE are very much intertwined, and hence I consider them concurrently. I also consider implications for future research, and the contribution of the study to the field. Finally, I include a personal reflection in light of my experiences.

Chapter 2. Literature review

2.1 Introduction

In this chapter, I review literature relevant to the topic of learning to teach science. Where possible, I include material from the field of science education, alongside more general material about teacher preparation. This is because I view science education as a distinct field within education, at least in part for philosophical reasons, as I hope to elucidate further in discussing the ontological and epistemological underpinnings of my research.

Malthouse and Roffey-Barentsen (2014) suggest that science teachers find it difficult to be reflective because they are positivists, and hence may tend to view teaching issues in black and white terms. Because this raises a question about science teachers' philosophical positioning, I have chosen to consider my ontological and epistemological assumptions at the beginning of this chapter, rather than waiting until the methodology chapter.

Since one of my *prima facie* RQs was 'What are the barriers that physics PSTs face during their PGCE?', I then consider potential difficulties for science PSTs. I refer to literature about difficulties with science teaching, both for experienced science teachers and PSTs. I also consider what we can learn about science teacher development and preparation from previous research. From a practical perspective, understanding the barriers for science PSTs, and knowing what is recommended for their development, may help us to support them better during their ITE courses. This might help us to tackle the chronic shortage of science teachers (and physics teachers in particular). One of the conditions suggested for science teacher development is opportunity to critically reflect, and hence I begin to introduce ideas about reflective practice in this section. Because aspects of reflection underpin the teaching intervention and data analysis, these ideas are developed further in subsequent sections.

I then introduce the theoretical underpinnings of the teaching intervention, which are:

- The DTC (Tripp, 1993)
- AL (Bayley, 2015; Aubusson *et al.*, 2009)

Subsequently, I consider the theoretical underpinnings of the analytical frameworks. In analysing the extent to which PSTs are reflective, I refer to Zwozdiak-Myers' nine dimensions of reflective practice (2012). Within this discussion, when considering PSTs' ability to link theory and practice, I use Korthagen and Lagerwerf's model of three levels of teachers' professional learning (Korthagen and Lagerwerf, 2001). I consider PSTs' development on the programme in terms of Furlong and Maynard's stages of development of PSTs (Furlong & Maynard, 1995), which includes reference to development of their CBM.

I end the chapter by explaining how the RQs were modified in light of carrying out the literature review.

2.2 Ontological and epistemological assumptions

In common with my students, I have a science background – having studied Natural Sciences as an undergraduate. When we undertake ITE we begin to change fields, since we move from the sciences into the social sciences. In my own case, subsequent to my PGCE I completed a master's in science education whilst working as a teacher, and after changing career into science teacher education I completed a postgraduate certificate in academic practice, as a preparation for teaching in higher education. I am now in the process of completing an Ed.D., all of which I would suggest have moved me further from the field of science and towards the field of education, sitting within the social sciences.

The PSTs with whom I work are preparing to teach science, so it is possible that I will always have a foot in both camps. I think that where science teaching is more effective, teachers' views of the NOS underpin their approaches to teaching (Osborne & Dillon, 2010), and in an ideal world my teaching of science PSTs would also be faithful to my understanding of the NOS. But I am also an educator, and thus my educational practice with science PSTs should reflect my understanding of how adult learners develop their teaching. On the PGCE courses on which I have taught, there has also been an ethos of modelling teaching approaches that we would like PSTs to adopt because they are understood to be examples of good practice. Thus,

my teaching would, ideally, also reflect my understanding of how children learn in science.

In this section, I first discuss the NOS, and then discuss how I position myself in the educational research that I am conducting. I would like to be able to resolve the tension I experience about having a foot in two camps.

2.2.1 What is the nature of science?

A work about the NOS could be a thesis in itself, so I note that I am only able to scratch the surface here. It is quite possible that I will over-simplify some areas of complexity as a result.

Malthouse and Roffey-Barentsen (2014) suggest that science teachers may have a difficulty in being reflective because they have a positivist epistemology. I think that Malthouse and Roffey-Barentsen may refer to logical positivism. This is a position where it is believed that scientists can make objective observations of the world, and that from these observations the laws of nature can be found by deductive logic (Bird, 2006). Positivism is an epistemological position which may go together with the ontological position of realism, in which it is assumed that there is a material world that exists outside of human minds, about which we can make discoveries (Osborne & Dillon, 2010).

In the philosophy of science, there are two main difficulties with logical positivism. The first is that it requires that scientists should limit themselves to describing what they have observed, without inventing theories or concepts to explain them. An example was the reluctance of positivists to adopt the atomic theory, despite its excellent explanatory power in relation to the observation that substances react in certain proportions (Bird, 2006; Osborne & Dillon, 2010). Secondly, there is a question over the extent to which different observers can agree about what has been observed. Indeed, there is discussion about the extent to which the theories held by the observers affect their perception and interpretation of that which is observed. The extreme position, which holds that different observers may literally see something different because they have different theories in their minds, is referred to as the theory dependence of observation, or sometimes the theory-laden-ness of

observation. This position is often attributed to Hanson and Kuhn (Brewer & Lambert, 1993).

An alternative to realism is relativism. Kuhn's theory of scientific revolutions holds that there are two types of episode as scientific knowledge develops through time (Kuhn & Hacking, 2012) – periods of normal science are interspersed with episodes of revolutionary science. During periods of normal science, the field develops according to certain norms and rules, which are agreed by those working in the field. Thus, there is a sociological element because the community of scientists working in the field shares these norms and values. It is into this community that new scientists are inducted as they are trained – learning about standard experiments and being introduced to ideas held by experts in the field. The way that scientists understand the field to be during the period of normal science is referred to as a paradigm. Over time, anomalies may arise which cannot be explained within the paradigm. Eventually this may lead to a paradigm shift during the period of revolutionary science, since a new paradigm may be needed to explain the anomalies.

Bird's (2006) criticism of relativism is that it is an irrational position since it is not possible to express a preference for one theory over another. Each theory is correct within its own paradigm, and hence there would not really be an advance in scientific knowledge with the paradigm shift.

To support realism, he offers us 'inference to best explanation' (Bird, 2006: 282). Whilst acknowledging that a given explanation could later be superseded by another, if we have an explanation that is currently agreed to be the best available, and if this explanation relies on particular scientific laws and data, then we assume for the time being that they are all correct. This reasoning relies on a reliabilist epistemology, which is that if the scientific method upon which we base our knowledge is believed to be a reliable method then our knowledge can be inferred to be correct.

Giere (2006) discusses the epistemological position of scientific objectivism (that there are universally applicable laws of nature that can be discovered) in opposition with constructivism (that science is a human construct). He suggests that this debate is the source of conflict between the viewpoint of scientists and the viewpoint of

social scientists, since many scientists take an objectivist view, whereas social scientists tend to take a constructivist position.

Giere (2006) suggests that there is a third way, which is perspectival. He develops his argument within a naturalist framework, i.e. one which does not appeal to the supernatural and which regards all claims as fallible. Two underpinning ideas of his view of the NOS are that 'scientists use [representational] models to represent aspects of the world for various purposes' (Giere, 2006:63) and that scientific theories involve the application of models to the world.

Examples of representational models include the Bohr atom, and Crick and Watson's physical model of DNA: They are the tools used by scientists to describe what an aspect of the natural world is like. Figure 1 shows Giere's 'overview of the model-based account of theories' (Giere, 2006:61).

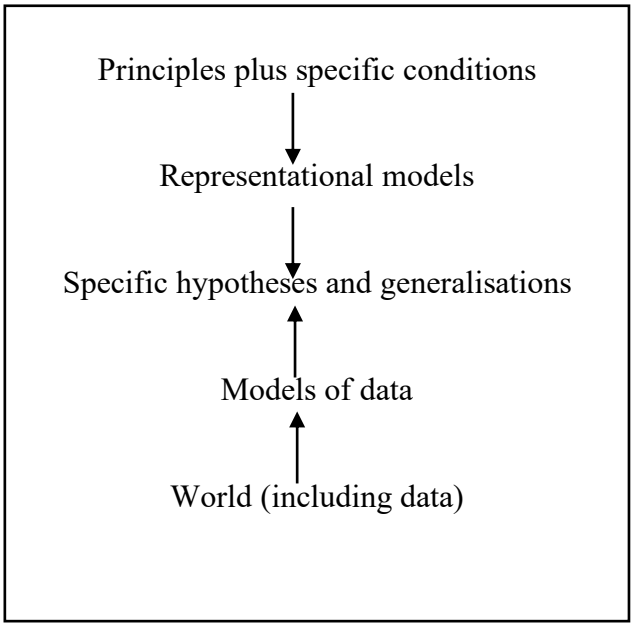

Figure 1: Giere's model-based account of theories

Giere (2006) argues that observations of the world are perspectival for two main reasons. Firstly, because there is an interaction between the human observer and that which is observed, not least because observations are made using the senses, which have evolved to respond to certain stimuli owing to natural selection. Secondly, data gathered using instruments are perspectival because different instruments are designed to respond to certain types of input. An example is the different

wavelengths of electromagnetic radiation used in different telescopes by astronomers, which give us different views of astronomical objects such as galaxies. No one image of the galaxy can be said to be a true image showing us the real galaxy.

He extends this argument to the idea that scientific theories are themselves perspectival. His view of principles is that they are not empirical laws, but rather that they are abstract generalisations about the quantities or entities involved in the model. For example, Newton's laws of motion are not universally true, but rather are an abstract generalisation about how physical objects behave from the perspective of classical mechanics. Since theorising involves the interaction between principles and representational models that are perspectival, with data and models of data that are perspectival, theories themselves are perspectival.

Overall, I do not consider the positions of Bird and Giere to be incompatible with one another. Both would appear to accept that there is a real world, i.e. they adopt a realist ontology. Whilst Bird focuses on methods that are generally considered to be reliable by the community of scientists, Giere goes a step further and includes the idea that the outcome of any scientific method has a perspective that is dependent both on the social world (since the work is carried out by evolved beings), and on the capabilities of the instruments used. Effectively, my position as a natural scientist is perspectival realism.

2.2.2 How do I position myself in educational research?

Waring (2012:16) describes ontology in educational research as asking 'What is the form and nature of the social world?' As someone with a scientific background I might question whether there is a social world which can be treated separately from the natural world as a whole. The natural sciences study the natural world, and human beings are organisms which have evolved within this natural world. From this perspective, any study of human beings could be viewed as sitting within the study of the natural world itself. It might be argued, therefore, that educational research is a type of socio-cultural anthropology (sitting within the natural sciences).

I was initially somewhat attracted to Adey *et al.*'s (2004) description of how scientific research and educational research sit in relation to one another. The authors describe a continuum of certainty, with Newtonian mechanics at one end (which works to a large extent, until you have to make relativistic adjustments) and with astrology at the other (a field which scientists would consider to have no certainty whatsoever). On this continuum lie the fields of economics and meteorology, both of which now have greater predictive power than they used to because mathematical modelling has become more sophisticated. Of these, meteorology is the less certain because by-and-large we lack the means to adjust the weather. However, we do have levers that affect the economy, such as taxes and interest rates. The authors suggest that educational research lies somewhere between economics and Newtonian mechanics on this continuum. It cannot give us the certainties that we have in mechanics, but it may be better than economics because 'there is a good degree of predictability' (Adey *et al.*, 2004: 146). The authors consider themselves to take a philosophical view between positivists and post-modernists, where post-modernism is characterised by relativism.

According to Waring (2012) the search for predictive power would tend to put Adey *et al.*'s position somewhere in the direction of positivism on a continuum between positivism and interpretivism. The emphasis on predictive power perhaps belongs with hypothetico-deductive reasoning, which is only one type of reasoning used in the natural sciences. Arguably, Bird (2006) and Giere (2006), above, used abductive reasoning.

Within educational research, the research design that would fit most closely with hypothetico-deductive reasoning would be quasi-experimental: seeking evidence of the effect of one variable on another. Whilst such investigations can tell us 'what' is the effect of X on Y, other educational research designs may be better able to answer questions about how this happens (Hood, 2007; Yin, 2014).

I suggest that the question of predictive power touches on generalisability. Some scientific reasoning may rely on statistical methods and probabilities based on large sample sizes to tell us about the extent to which variable X affects variable Y (Giere, 1984). However, qualitative research methods in education make claims to generalisability differently. In grounded theory, for example, Hood (2007) argues

that it is the richness of description in the cases under consideration that enables the reader to decide whether or not they think conclusions are likely to be more widely applicable. Again, such thinking appeals to abduction – the reader must infer from the data available whether or not they think the conclusions are likely to apply more generally.

I see no conflict with Giere's (2006) perspectival epistemology. It would be possible to extend Giere's argument about the perspectival nature of scientific instruments to the instruments of educational research. Similarly, there would be an interaction between the human observer and that which is observed in social scientific research.

Hence, if there is a continuum between positivism and interpretivism, I would say that my own epistemological position lies further towards interpretivism than that of Adey *et al.* (2004).

It is possible that there is an alternative to positivism and interpretivism, which is critical realism (Denzin & Lincoln, 2011). Within critical realism one assumes:

- Ontological realism, i.e. that there is a real world that exists independently of human beings
- Epistemological relativism, since meaning is made by the social scientist about the social community being studied – where the points of view of the people being studied are also constructions
- Judgmental rationality, i.e. that human beings are capable of using criteria to decide between competing theories (Bhaskar, 2017)

In attempting to explain the distinction between natural sciences and social sciences, Bhaskar (2017) points to differing assumptions, within a critical realist perspective. In the natural sciences there is distinction between a transitive world and an intransitive world. The intransitive world refers to objects and processes that would continue to exist if there were no human beings (for example, oxygen-16 would still be composed of 8 protons and 8 neutrons). The transitive world in the natural sciences refers to things which may change over time, such as the paradigm shift from a geocentric to a heliocentric solar system (Anon., 2009). I suggest that this view is compatible with Giere's perspectivism, since he acknowledges the transitive nature of observations made with instruments (since new instruments are invented),

as well as conceptions of those observations made by human observers (since ideas develop as new data come to light). In the social sciences, however, the social world is transitive – for example, because both the structure of a society and the individuals within a society are capable of changing over time.

I tend to agree with Bhaskar (2017) that in the natural sciences there is a real world, which exists outside the mind. He considers Hume's problem of whether to leave the building by the second floor or the ground floor to be unserious. We know that, given the choice, we will always leave the building via the door on the ground floor, rather than the second floor window. There is no doubt in our minds that gravity will continue to work. Ergo there is a real world, and it is agreed by all.

Critical realism proposes that there is a real world, both natural and social. It distinguishes between the real, the actual and the empirical. Sayer (1999:11) states that 'the real is the realm of objects, their structures and powers' (where powers might be described as that which they are able to do, even if they are not currently doing it). The actual refers to events or experiences that happen when objects or structures use their powers – 'the actual domain [is one] where events happen whether we experience them or not' (Danermark, Ekstrom & Jakobsen, 2005:20); and the empirical is that which can be observed (Sayer, 1999; Bhaskar, 2017). To extend Bhaskar's example about gravity to the social world, I would tend to suggest that the question of whether or not there is a real world in social sciences is also somewhat unserious. An example analogous to gravity would be tax systems. I suggest that the majority of people continue to pay taxes because they accept that if they choose not to do so, and it is noticed by some arm of government, then there will be consequences. Ergo there are some objects, structures and powers in the social world, which are commonly agreed to be real.

In common with interpretivism, critical realism acknowledges that people make meaning of the social world, i.e. they both accept epistemological relativism. There is a social world in the natural sciences – the scientific community within which scientists work, as noted in relation to Kuhn's theory of scientific revolutions (2.2.1). In the social sciences, we must consider both the community of social scientists within which we work, as well as that which we are researching. Sayer (1999:17) refers to this as a 'double hermeneutic'. In the natural sciences, however, nature's

mechanisms continue to work regardless of what we think about them, which is referred to as a 'single hermeneutic' (Danermark *et al.*, 2005:32).

Where Bird (2006) was critical of relativism in natural sciences, since it offered no means of deciding which theory was best, some within the social sciences were critical of postmodernism for similar reasons. According to Sayer (1999) the main objections to judgmental rationality are:

- The theory-laden-ness of observations
- Incommensurability – i.e. that when paradigms change, people within competing paradigms are unable to communicate with one another because they define terms differently

In relation to the first of these, Sayer (1999) points out that just because scientists' observations may be coloured by their understandings of the world (i.e. theories), observations are not necessarily determined by them. A key starting point for Bhaskar's argument is 'the fact that there has been successful scientific practice' (Pearce & Frauley, 2007:12). The example given is that we have technological advances, such as aeroplane travel. One of the ways in which scientific endeavour proceeds is through empirical research. I tend to agree with Sayer (1999:47) that 'it is hard to see why observations would ever be necessary… if our concepts already specified everything about what could be observed'. Hence observations are not entirely determined by theory, and therefore are not so dependent upon theory that the theory-laden-ness of observation prevents judgmental rationality.

Bird (2000) had already given one way of overcoming the problem of incommensurability, which was inference to best explanation (2.2.1). Bhaskar's argument here is that there can be no disagreement about theories which cannot be compared because people use language differently (Bhaskar, 1979, cited by Sayer, 1999). He therefore suggests that the problem of incommensurability has been interpreted too literally, and that at worst it may be used to close down discussion of new theories. Whilst there may be few (or no) absolute truths, we are not prevented from making decisions about which theories best describe that which is observed, to the extent to which we are able to agree upon what has been observed.

To summarise, critical realism is a position which unites the natural sciences and social science to an extent because, in this paradigm, it is possible to adopt ontological realism and epistemological relativism. The difference is in that the natural world has both transitive and intransitive elements, but that the social world is entirely transitive. Since the objects of the social world are defined by people, who may interpret them differently from one another, social science research is affected to a greater extent by the interaction between the observer and the observed. The implications of this paradigm for research methodology will be discussed further in the relevant chapter (3.2).

2.3 What do we know about science teacher development?

Since one of my initial questions was 'What are the barriers that physics PSTs face during their PGCE?', I begin by reviewing concerns raised about science teaching in previous research, including particular difficulties identified for PSTs. In the second part, I consider what we know about science teachers' development, and the conditions that support it.

2.3.1 In what ways might science teaching need to be developed?

Much research into science teaching seeks to improve it (Bell & Gilbert, 1996; Davis, 1996; Trumbull & Slack, 1991; Baird, Fensham & Gunstone, 1991; Olson & Finson, 2009; Loughran, 2007). The main concern expressed is that science teachers default to teaching in the way that they were themselves taught, which was often by transmission and rote learning. It is suggested that science teachers may have preconceived ideas about science teaching and learning – that children learn scientific ideas merely by being told the accepted scientific view. Loughran (2007:1043), for example, writes that there is:

> …a long tradition of science teaching as telling that has been so pervasive in schools, characterised by the stereotypical view of the transmission of science as propositional knowledge.

Such approaches may contribute to a number of difficulties, notably failing to overcome children's alternative conceptions; and failing to overcome their naïve views about the NOS. Furthermore, the outcomes of transmission modes of teaching may put some children off science, since they do not take into account how they learn. This may contribute to the fact that science education appears to carry out a

filtering function, whereby underrepresented groups (such as female and minority ethnic students) are progressively removed from the system (Trumbull & Slack, 1991).

Regarding children's alternative conceptions, there is a rich vein of science education research (see, for example, Driver *et al.*, 2007) suggesting that children have naïve ideas about the world, which they bring with them to their science lessons, and which may be difficult to change. Researchers (such as Loughran, 2007) make the case for teaching science for understanding, since if children understand the underpinning scientific ideas better there is a greater likelihood that they will be able to apply their knowledge to novel situations. Whilst a number of strategies for teaching to overcome alternative conceptions have been suggested in the field of science education, it is by no means clear that there is one best method. However, Di Sessa (2014) suggests that outcomes are better where science teachers are aware of children's ideas.

In terms of the view of the NOS that transmission modes of teaching support, it is suggested that they reinforce a naïve view that:

- Science knowledge is unproblematic
- Science provides right answers
- Truths in science are discovered by observing and experimenting
- Choices between correct and incorrect interpretations of the world are based on commonsense [sic] responses to objective data (Carr *et al.*, 2013:161)

An alternative is to consider scientific ideas as constructed. This view positions scientific endeavour as an activity done by people, who collectively create scientific knowledge, which may be adapted over time as new technologies and methods produce new evidence, which itself interacts with theory.

Having said that there is not consensus around how to teach for understanding, a range of constructivist teaching approaches are suggested, which may include:

- Eliciting pupils' ideas
- Dialogic teaching, built around classroom discussion and questioning
- Allowing guided discovery and enquiry, rather than illustrative practical work
- Teaching which is responsive to pupils' interests and understandings

- Teaching which aims to foster higher-order thinking, rather than merely recall

See, for example, Brooks (1999).

Interestingly, Malthouse and Roffey-Barentsen (2014) suggest that science teachers' philosophical view may be related to their difficulty in being reflective. I found this point to be of interest because it is a possible explanation for PSTs doing less well on teacher preparation courses which adopt a reflective practitioner model of how people learn to teach, in comparison with their more reflective peers.

Malthouse and Roffey-Barentsen argue that PSTs' difficulty in being reflective is caused by the fact that their science backgrounds position them as positivists, one manifestation of which may be that PSTs think that there is a right answer as to how they should teach. They suggest that PSTs come to teacher preparation courses expecting tutors and mentors to be able to tell them the right answers about what to do, that they will then apply them, and that they will then be good teachers of science. They go so far as to say that PSTs 'don't see the point of reflective practice', and ask 'Are science teachers immune to reflective practice?' (Malthouse & Roffey-Barentsen, 2014:166 & 161).

My professional experience suggests there may be some truth in this argument. Feedback from one science PST on an employment-based route into teaching, for example, was 'Nobody seems to be able to tell me WHAT to teach or HOW to teach it', which tends to support the suggestion that they think there is a right way to teach. However, I did not find the research evidence on which Malthouse and Roffey-Barentsen's conclusion was based compelling. One of the studies cited was conducted with undergraduates in the USA who were preparing to be primary school teachers (Olson & Finson, 2009); and another was conducted during a five-year course of training in Turkey (Efe, 2009). Perhaps owing to cultural differences, differences between education systems, and differences in modes of teacher education we might question the extent to which their findings apply to people on a one-year secondary postgraduate programme in England. A second question mark was about the way in which reflectivity was assessed. Since Olson and Finson (2009) had assessed reflective essays, I wondered whether the outcome suggested a lack of ability to reflect, or a lack of ability to write reflectively. Additionally, Efe

(2009) suggested that science PSTs became more reflective as they gained school experience.

Furthermore, when Malthouse and Roffey-Barentsen (2014) say that science PSTs are positivists it is not clear to me whether they mean that science PSTs are naïve realists or critical realists. A naïve realist has a simplistic view that science is composed of factual information, which is literally true, whereas a critical realist recognises the limitations of scientists' observations, as well as the limitations of interpretations of these data (Osborne & Dillon, 2014). I assume the former, however. The latter might be a reasonable philosophical standpoint for a scientist, as elucidated when I discussed my own epistemological and ontological assumptions (2.1).

Originally, my own thinking was that in any group of science PSTs there will be a range of philosophical positions, owing to their differing prior experiences. Some recent graduates have studied philosophy of science, and some have not. Some career changers have worked as research scientists, and therefore may have a more highly developed understanding of scientific endeavour than those who have not. However, the consensus in science education research literature is that there is a deficit in science teachers' understanding of the NOS (Cofré *et al.*, 2019). Additionally, Lederman and Lederman's (2014:604) review of research carried out in a variety of countries over several decades overall tends to suggest that science PSTs do 'not possess adequate conceptions of [the] nature of science'. Researching the views of science PSTs in Turkey, Adak and Bakir (2017:472) suggest that they have a 'traditional understanding of science based on [a] positivist paradigm'. So Malthouse and Roffey-Barentsen's suggestion that science PSTs are positivists may not be unreasonable.

Furthermore, Tsai (2007) notes that it has been suggested in science education literature that there may be a link between the teacher's epistemological view and their approach to teaching. Positivism tends to be associated with direct instruction, rote learning and an emphasis on test scores, whereas constructivism is associated with science inquiry, conceptual change and group work. However, the strength of connection between ontological and epistemological views and teaching approaches remains a matter for debate.

Baird *et al.* (1991:181) note that science is 'striving for the one correct explanation of a particular scientific phenomenon (or a method, etc.)' but that teaching and learning in science 'is more likely to be multiple (pluralistic) and content-, context-, and time-dependent (relativistic)'. They suggest that science teachers generally need to adopt a more pluralistic and relativistic view.

This tendency towards dualism – seeing the world in black and white terms – is also noted by Olson and Finson (2009) in their study with undergraduates. The authors attributed PSTs' lack of reflectivity to them operating at a low intellectual level on the Perry scale (Perry, 1999). Owing to the shortage of science teachers, the PGCE course at Green University accepted science PSTs with a weaker academic background (on average) than some other subjects, like history, English and PE, assuming that A level grades and degree classification indicate academic ability. There is a possibility that this weaker academic background is a co-determinant of their performance on the course.

I was not able to find other literature linking positivism with a lack of reflectivity *per se*. However, there is certainly some support in the literature for the suggestion that science PSTs may initially be reluctant to reflect (Corrigan, 2009), and that they may find it difficult to write higher-level reflections that are evaluative and interpretive, rather than descriptive (McFadden *et al.,* 2014). There is also research interest in methods to support science PSTs in becoming more reflective (see, for example, Barth-Cohen *et al*., 2018) which tends to suggest that others may also perceive there to be a deficit in their reflectivity.

A further difficulty identified for science PSTs during ITE is development of their subject knowledge (Gilbert, 2010). Most have to teach outside their specialism – often to GCSE level. Few have taken A Levels in all three sciences themselves. National data also suggest that 37.3% of physics teachers and 25.1% of chemistry teachers do not have a degree in the subject (Pells, 2017).

Shulman (1987) identifies seven types of teacher knowledge, of which content knowledge is one. He envisages the teacher as a scholar, whose understanding of the

discipline they teach includes not only facts or concepts, but also the structure of knowledge in the discipline, and an understanding of how knowledge is produced in the discipline (Shulman, 1986). Shulman sees this deep knowledge of subject content as a central feature of teacher knowledge.

Another important aspect of teacher knowledge Shulman identifies is pedagogical content knowledge (PCK). Different authors define PCK differently, but Van Driel, Verloop and De Vos (1998) suggests there is consensus around:

- knowing how to represent topics so that others can understand them, including 'analogies, illustrations, examples, explanations, and demonstrations' (Shulman, 1986:9).
- understanding pupils' difficulties and how to overcome them.

There is some evidence in the literature that PSTs may have similar alternative conceptions to those of the children they teach (Berg & Brouwer, 1991; Smith & Neale, 1989; Wandersee *et al.*, 1994). Both Finlayson *et al.* (1998) and Van Driel *et al.* (1998) argue that teachers must understand the topic themselves before they can represent the material appropriately to pupils, and before they are able to address children's alternative conceptions.

These suggestions might also help to explain why PSTs find it more difficult to learn to teach than their peers of other specialisms, since a greater proportion would appear to lack a level of knowledge of the subjects they are teaching going beyond that which they teach. Once they understand the subject matter, they still need to develop strategies for teaching it to children.

To conclude, literature suggests that potential barriers for science PSTs may be:

- Adopting transmission and rote learning modes of instruction (possibly linked to positivism), which may limit their pupils' progress
- A lack of reflectivity, possibly owing to operating at a low intellectual level on the Perry scale
- A lack of subject knowledge and pedagogical content knowledge

2.3.2 How might science teaching be developed?

What conditions might help science teachers to develop their practice? Dillon (2000) suggests some common features in the research about science teacher development, which include:

1. Teachers involved needing to feel dissatisfied in some way in order to engage with an intervention;
2. The need for 'input of new theoretical ideas and new teaching suggestions' (Bell & Gilbert, 1996: 34)
3. Opportunity to put these ideas into practice over an extended period of time
4. A critically reflective approach
5. Collaboration with peers and with a more experienced other

On the first of these points (dissatisfaction), Trumbull and Slack (1991) suggest that since PSTs have themselves been relatively successful as students of science, and because they may lack experience of working with young people in the classroom, they may not in fact be dissatisfied with the status quo.

Gilbert (2010) suggests that overcoming this problem involves both personal and professional development. Bell and Gilbert (1996:16) suggest a sequence of development of science teachers, composed of personal, social and professional dimensions, as shown in Table 1.

Phase	Social development	Professional development	Personal development
1	Seeing isolation as problematic	Trying out new activities	Accepting an aspect of my teaching as problematic
2	Valuing collaborative ways of working and reconstructing what it means to be a teacher of science	Development of ideas and classroom practice	Dealing with restraints
3	Initiating collaborative ways of working	Initiating other development activities	Feeling empowered

Table 1: A model of science teacher development

In personal development, PSTs have to confront the idea that children may not learn in the way that they were taught themselves, since they have often been taught according to behaviourist rather than constructivist principles. Adey (2010) might characterise this development as conceptual, rather than personal, since the

suggestion is that PSTs' ideas about learning in science need to be reconstructed and reconceptualised (Loughran, 2007).

To remedy this, Trumbull and Slack (1991) carried out an intervention in which they sought to create cognitive dissonance. PSTs developed interviews-about-instances which they used with peers and other adults. This may have helped them to see that the interviewees had misconceptions and misunderstandings which had not been addressed by science teaching; whilst simultaneously enabling them to see that they themselves had misconceptions, misunderstandings and gaps in knowledge. PSTs might have begun to question the norms in their own schooling as a result.

On the second point (input of new ideas), Gilbert (2010:277) states that professional development involves 'development of that repertoire of beliefs, knowledge, and skills that enable a sense of being a teacher of science to be exercised in everyday classroom practice'. Hence there is a need for PSTs to have access to information about pedagogical approaches that they might use, as well as having a willingness to try them out.

Given the challenge of developing subject knowledge and PCK, outlined previously (2.3.1), Gilbert (2010:291) suggests that 'a necessarily heavy load of information about the curriculum' should be provided in the initial phase. However, this is not as simple as telling PSTs what they need to teach and how to teach it since:

- Such an approach would not necessarily address PSTs' own alternative conceptions
- Adey (2010) suggests that effective professional development entails modelling those practices which we wish teachers to adopt.

There are certainly opportunities for PSTs to gain new ideas about theories of learning and strategies for teaching in university-schools partnership PGCE courses. In fact, I would suggest that these were the predominant activities in the university-based part of the PGCE at Green University. However, learning subject-specific strategies for teaching is likely to be problematic for two main reasons. The English National Curriculum is traditionally seen to be content-laden (Toplis, Golabek & Cleaves, 2010), and the time available in which to teach about it is limited – since there are only 12 weeks in the university, and a proportion of that time is devoted to

generic, rather than subject-specific material. That said, Kind (2009) suggests that PSTs often rely on materials for teaching found in their schools. Arguably, however, the time PSTs spend teaching in schools is also quite limited (being 24 weeks), and they do not teach the full range of topics during their ITE year. Owing to teacher shortages there may also be a lack of expert knowledge of teaching some sciences in some school placements. I suggest that, overall, PSTs probably have insufficient access to ideas about subject-specific pedagogy.

On the need for an extended period of time for teacher development to take place, writing about training courses for qualified teachers, Adey (2010:361) goes so far as to say that 'the one-shot…training… day is a complete waste of time for bringing about any real change in teaching practice or student learning', recommending 30 hours over a two-year period. Bell and Gilbert (1996) suggest that it is not very common for teachers to be given the amount of time they need. This is likely to be problematic on a one-year PGCE course, particularly because PSTs spend only 24 weeks on teaching practice in schools. There is not much time available to practice new teaching approaches.

We have already seen that it is possible that reflection is a weakness for PSTs. Bell and Gilbert (1996) suggest that opportunities for critical reflection and collaboration are uncommon in teacher development programmes. However, this may not necessarily be the case in ITE.

Reflective practice has long been considered to be an essential component of teacher development, within and beyond the UK. Wilkin (1996), for example, suggests that prominent academics, such as Pring, were advocating reflective practice by the mid-1970s. Twenty years later, the Modes of Initial Teacher Education study (MOTE) found that 70% of teacher preparation courses in England adopted reflective practitioner models, and their adoption was believed to be increasing (Furlong & Maynard, 1995). They suggest that there are two broad types of reflective practitioner model, which are Deweyan and Schönian.

Furlong and Maynard (1995:57) characterise the Deweyan model as involving 'systematic enquiry into one's own and others' actions'. They perhaps imply that the

Deweyan model involves reflection after the event, however Dillon (2007:100) suggests that reflection 'during the act of teaching' is implicit in Dewey's writing.

The Schönian model is certainly metacognitive in nature. Schön (1987) argues that practitioners' work involves dealing with complex problems, and he develops a number of concepts to help us understand how practitioners resolve them. He refers to the skills that professionals carry out without conscious thought as 'knowing-in-action' (Schön, 1987:22), and says that we may in fact not be able to put our professional knowledge into words. However, we may come up against unexpected situations while we are working, about which we may have to think. He refers to these episodes as 'reflection-in-action' (Schön, 1987:26). Again, teachers may not be able to put this decision-making process into words – these are judgment calls which are made rapidly in the normal course of their work. Additionally, professionals work within particular social and institutional contexts, and therefore need to be able to apply their theoretical knowledge about education to both new and familiar situations – a phenomenon he calls 'knowing-in-practice' (Schön, 1987:33). It has been suggested that we may develop our professional practice by reflecting on what has happened after the event – referred to as reflection-on-action (see, for example, Baird *et al.*, 1991) – that this will enable us to improve our decision-making. In this model, the process of becoming a teacher can be thought of as learning to think like a teacher.

Atkinson (2004:381) distinguishes between three levels of reflection:

- Simple reflective practice, which involves the individual teacher reflecting upon their teaching in order to improve
- Reflexive practice, which also considers the effect of systems and process within the school concerned
- The critical practitioner, who is also able to consider challenges at a system-wide level, 'interrogating political, ideological and social processes that frame educational work'

I suggest that the PGCE course at Green University intended to develop reflection at each of these levels. For example, at the simple level, PSTs were routinely required to complete written evaluations of their lessons. By returning to the university setting for a period after the first school placement, PSTs were able to compare and contrast

policies in different schools with one another, which may have facilitated reflexive practice. At the more critical level, some of the material in both subject seminars and professional development lectures and seminars included consideration of national frameworks, such as the school curriculum. PSTs were also required to complete weekly written reflections about these seminars.

Some of the literature points to collaborative reflection being potentially helpful. Working collaboratively was included in Bell and Gilbert's social dimension of development, which they suggest involves 'seeing the value of collaboration with colleagues, such that mutual critically supportive dialogues can occur' (Gilbert, 2010:278).

Baird (1992) writes about teacher development more generally – including, but going beyond, initial development of science teachers. His conclusions are based upon two longitudinal research projects involving up to 70 teachers, which collected and analysed a large quantity of data of different types, such as diaries, interviews, questionnaires and written evaluations. Whilst science education research emphasises the need for teachers to re-conceptualise what science teaching means, Baird additionally identifies an affective component, which includes development of traits such as confidence and self-assurance. Baird also argues that teacher development must include active enquiry.

Arguably, Baird's (1992) research projects went beyond what might be achievable in a university-schools partnership PGCE course. Participants met weekly or bi-weekly, and were initially supported by an academic. This schedule represents a significant time commitment from all parties. There was also ongoing phenomenological reflection by the teachers, and feedback was regularly sought from pupils.

So what might be possible in the context of a PGCE course? Writing about such PGCE courses around the time at which they changed into their current form (after Department of Education and Science Circular 3/84 (DES, 1984)), Rudduck (1992) identifies three ways in which PSTs were involved in collaborative, reflective research during the course on which she worked:

- Paired placements – which gave PSTs opportunity to carry out mutual observations and feedback.

- Analysis workshops – in which PSTs worked in groups to discuss educational topics in light of their school-based experiences, and research evidence.
- School-based research projects – in which PSTs worked in groups to investigate topics of interest to placement schools.

To conclude, literature suggests that some of the conditions needed for science teacher development to take place might be dissatisfaction; the input of new ideas; an extended period of time over which to put them into practice; a critically reflective approach; and collaboration with others (Dillon, 2000). Science teachers may need to develop personally, professionally and socially (Bell & Gilbert, 1996). Additionally, there may be an affective component to development, which may be supported by active enquiry (Baird, 1992). Active enquiry might take place through mutual observations and peer feedback; as well as opportunities to work collaboratively on analysis and enquiry tasks (Rudduck, 1992).

In this study, I implemented a teaching intervention intended to support development of PSTs' reflectivity. To an extent, this was a pragmatic decision based on my professional experiences working with PSTs on several different modes of ITE. The reason for this choice will be further developed when introducing theoretical underpinnings of the intervention (2.4). Aspects of reflective practice are developed further in that section, as well as in the context of theoretical underpinnings of the data analysis (2.5.1), because I use Zwozdiak-Myers' (2012) nine dimensions of reflective practice as an analytical framework.

2.4 Theoretical underpinnings of the teaching intervention

In this section I introduce the theory informing the intervention. It had two components, which were Tripp's (1993) DTC and AL (Bayley, 2015; Aubusson *et al.*, 2009). I describe what these elements involve, as well as presenting their theoretical bases, and giving some explanation for selecting them.

2.4.1 Theoretical underpinning of the diagnostic teaching cycle

The model of classroom-based enquiry I used with PSTs was Tripp's (1993) DTC. In this section, I give my rationale for choosing this model, discussing its theoretical underpinnings and describing what it entails.

As mentioned in the introduction (1.1) the DTC was one model of reflection that was suggested to PSTs on the Teach First course. I worked on that programme as a science tutor and coordinator for two cohorts of science PSTs in a previous post, from 2011-2013.

I was particularly interested in Tripp's model (Tripp, 1993) mainly owing to his interest in applied research in education, having himself studied at Green University, where his influences included Lawrence Stenhouse. He described a career trajectory similar to my own, in that he had worked in schools for a considerable period prior to working with teachers in a university setting. I think this background lends itself to a particular perspective on the problem of the theory-practice divide. I had completed a part-time masters in Science Education whilst working in my first teaching post. Although I found it to be an excellent programme in terms of what I learned about the field, I became acutely aware of how difficult it was to put what had been learned into practice after completing the programme. Tripp proposes the DTC as a vehicle for overcoming the theory-practice divide.

Tripp (1993) describes having introduced potentially relevant educational research to in-service teachers as part of a classroom research module. Topics included 'self-fulfilling prophecy, group work, questioning strategies and sexism' (Tripp, 1993:xxi). Unfortunately, he found that teachers often claimed that what had been found in the research did not match well with observations in their classrooms. In response, Tripp (1993) asked teachers to keep critical incident diaries recording events in their professional lives that seemed important, or challenging, to them. He suggests that the interests of teachers are quite different than the interests of educational researchers. This led him to abandon deductive approaches based on application of educational theories, and to adopt an inductive approach, developing theory from teachers' experiences of teaching.

This is where Tripp and I take divergent views, possibly because my work is within the field of science education. Dillon and Osborne (2010) make the case that there is a substantive body of knowledge in this field which could usefully inform teachers' practices. Specific examples include Shayer and Adey's work on Cognitive Acceleration in Science Education (CASE, Shayer & Adey, 1981), Driver's work on understanding children's conceptions of science (Driver *et al*., 2007), and Black and Wiliam's work on AfL (Black & Wiliam, 1998). There is some evidence that the foundation disciplines of psychology, sociology, philosophy and history of education can be applied to improve science teaching. For example, Shayer & Adey (1981) drew upon psychological theories – Inhelder and Piaget's (1969) work on cognitive development, as well as Vygotsky's (1978; 1986) social learning theory – to develop an intervention which improved children's learning in science.

Having said that I was struck by the difficulty of putting theory into practice whilst working in schools, I did have positive and successful experiences of implementing both CASE and AfL. For example, the first cohort of pupils to experience the CASE programme in the school in which I was teaching went on to achieve the best GCSE results the school had ever had. I appreciate that other factors contributed to that success, however, as it is not possible to control all the variables over time in a school setting.

Although my view diverges from that of Tripp (1993), I think there may be merit in the model of professional learning he suggests. He uses critical incident diaries, where teachers identify perplexing situations that have arisen in their work. They then read and discuss the incidents in an 'action enquiry group' (Tripp, 1993:xv). Periodically, some of the critical incidents from the diaries are analysed in more detail, e.g. using Tripp's 'Kinds of judgement and analysis' (Appendix C, Tripp, 1993:27). In addition, he suggests a number of more structured thinking strategies that could be used in the analysis (Appendix D). The analysis of critical incidents forms part of a mode of classroom-based enquiry that Tripp calls 'the diagnostic teaching cycle' (Tripp, 1993:32) in order to develop ways of overcoming the original difficulty (Fig.2, p.40).

Tripp acknowledges the similarities of his approach to Argyris and Schön's double loop learning (Argyris & Schön, 1974). Single-loop learning involves routines that

people apply to bring about a particular outcome in a particular situation. Much of our activity is carried out in this mode as it does not involve a great deal of thought, and is therefore efficient. Argyris and Schön (1974:6) describe the way that we behave in a given situation as our 'theories-in-use'. If we wish to bring about a change, we need to examine these theories and modify them, developing hypotheses and testing them by experience, a process which they describe as double loop learning.

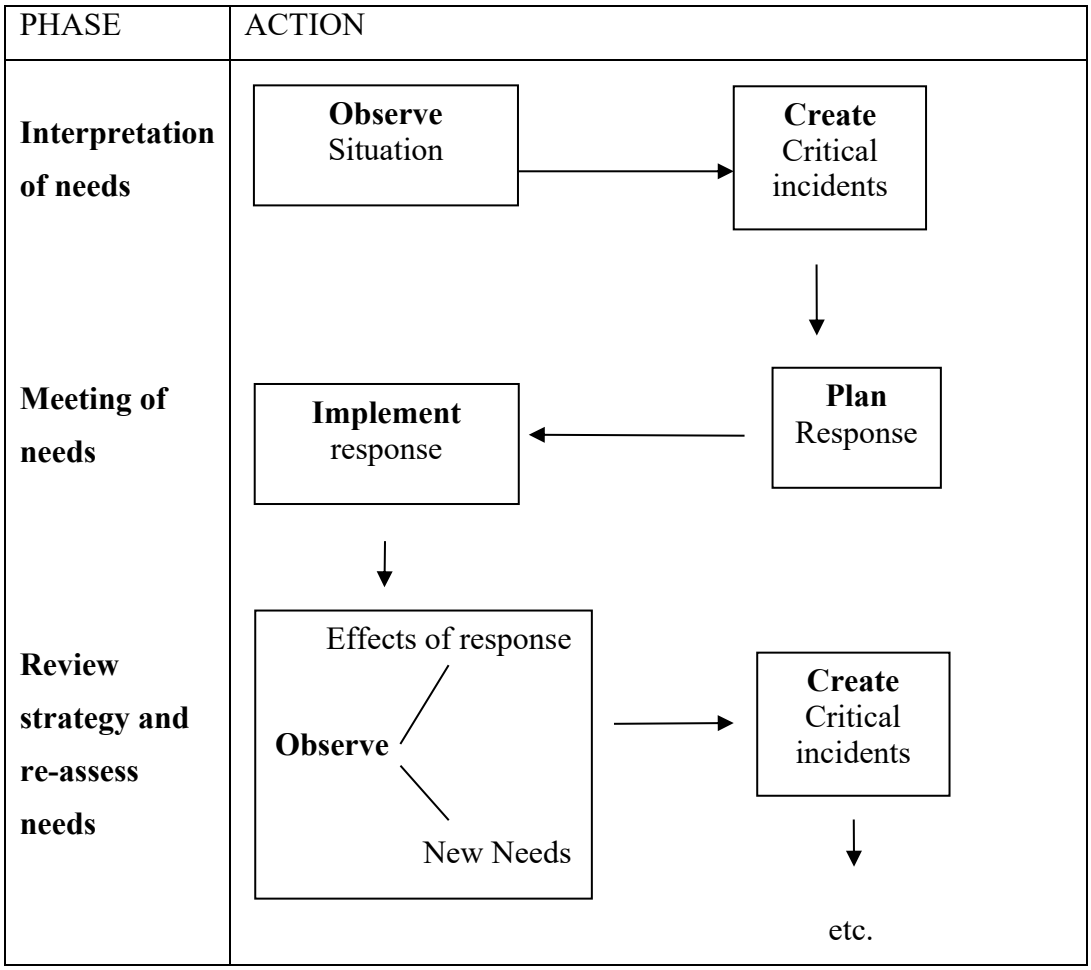

Figure 2: The diagnostic teaching cycle

Tripp (1993) adds to Argyris and Schön's approach in that he identifies an emotional element to teachers developing their practice, as well as a cognitive one. In so doing, he draws upon Dewey, concluding that 'reflection is… the term we should use for our processing of emotion' (Dewey, 1994, cited by Tripp, 1993:xii). The inclusion of an emotional element, is of interest because Baird *et al.* (1991) had also suggested that teacher development has an affective component.

By adding an initial loop where teachers come to terms with their feelings about situations, Tripp builds upon Argyris and Schön's double-loop learning and hence describes 'triple-loop learning' (Tripp, 1993:xviii). Tripp acknowledges that he does not give much information about the process by which participants come to terms with their feelings. I infer that this is part of the function of his group discussion, as well as part of his role as academic partner in the teachers' analysis of their practice.

In this study, I have brought together the DTC with AL, as I describe in the next section.

2.4.2 Theoretical underpinnings of action learning

In this section, I explain the rationale for choosing AL as an intervention with PSTs. Whilst the process was developed in industry, it is possible to view it as underpinned by educational theories, which I also elucidate.

As mentioned in the introduction (Ch.1), I think reflection was relatively well-developed in the Teach First programme. However, I think PSTs reflecting in isolation for an assignment might be a relative weakness in comparison with university-schools partnership PGCE courses, on which there may be more frequent opportunities to meet and discuss teaching with peers.

AL came to my attention during AY2014-15 at the Green University secondary PGCE mentoring conference (Bayley, 2015). It was subsequently introduced to all PSTs in AY2015-16, in a lecture in the Professional Development (PD) programme, as part of the course development process. The rationale given was that:

- "[Action learning] provides a forum where you can voice and work through your challenges and concerns.
- …it facilitates you as mentees forming your own strategies to work through an issue.
- The whole group will learn from the reflective process.
- Action Learning aids in the development of confidence, a growth mindset and resilience." (Bayley, 2015:15)

A trial of an AL set took place in a PD seminar after the lecture. The AL set is a group discussion for supporting professional learning. PSTs were about to start their

first school placements full-time (referred to as block placement). They worked in groups of 4-8 students, using a protocol suggested by Bayley (2015, Appendix E).

I repeated the process when my tutor group of science PSTs returned to Green University at the end of first placement. In AL, it is intended that participants take action to overcome their teaching issues, however, these initial trials somewhat lacked an action phase. Nevertheless, feedback from PSTs suggested that the AL set was received positively. I became interested in exploring its potential to help PSTs solve the challenges they face during their training year. Additionally, using AL in the research project may provide justification for retaining it in the PGCE course at Green University.

AL is an approach that has been translocated from industry/business. Writing about AL as part of the continuing professional development of qualified teachers, Aubusson *et al.* (2009) describe it as having been successful in coal mining and in improving a Formula One team. Hence one might question the extent to which it is likely to be helpful for teaching: Do we conceive of children's education as similar to mining or winning races? Are teachers producing educated products? Are they taking part in a teaching race? However, Aubusson *et al.* justify AL by linking it to theories of how teachers learn, referring to hundreds of case studies carried out in Australian schools. The authors state that 'in educational terms, action learning is underpinned by four main teacher learning processes – *reflection*, *community*, *action* and *feedback*' (Aubusson *et al*., 2009:41).

Reflection

It is suggested that the types of reflection usually recommended are done by individuals, whereas input from third parties can be helpful to challenge the underlying assumptions of the person doing the reflecting. Thus Aubusson *et al*. (2009) suggest that working in a group may be better than teachers working by themselves. These comments about reflection chimed in with my feelings about the reflective journal assignment, which I thought might have been more successful if the teachers had more opportunity to talk to one another.

Malthouse and Roffey-Barentsen (2014) suggested that science teachers are resistant to reflection. I thought that perhaps they would be less resistant if they had

opportunity to discuss their ideas with one another, rather than predominantly being asked to write.

Community

The authors' explanation of community suggests that social interaction is important for teachers' learning as well as for children's learning. This was of interest because the university-schools partnership PGCE courses on which I have worked teach PSTs about Vygotsky's theory of social constructivism – where there are benefits from working with peers and with more experienced others (Vygotsky, 1978; 1986). In light of my professional experience of PSTs appearing to benefit from the opportunities they have to talk to one another about their experiences in schools, it seemed to me not unlikely that the community aspect of AL would help them. It is also in tune with ideas about the importance of collaboration, described in the literature review (2.3.2).

The authors suggest that groups of 4-8 teachers come together to work on a common problem. This is slightly different than Tripp's intention for each group member to discuss their own teaching issue – which was more similar to that in material about AL used in PD at Green University. I think Tripp's suggestion is perhaps more applicable to the circumstances of science PSTs, who usually go to work in different placement schools on their individual teaching problems, rather than working on a common problem.

The framework suggested in the mentor conference at Green University was a coaching model – group members were encouraged only to ask open-ended questions of the presenter (Appendix F), and not to make their own suggestions of solutions. This differs from Aubusson *et al*. (2009:46), who envisage other group members making contributions: 'the ideas generated by action learning are enhanced when new ideas are introduced…from other team members'.

Additionally, Aubusson *et al*. (2009) depart from the model adopted in coal mining, for example, in which there was an emphasis on professional knowledge, rather than theory. The authors include contributions from an academic partner who supports in whatever way is needed: helping the AL group with choosing a focus; helping them to plan their action; suggesting research on which action might be based; playing

devil's advocate; and being critical. Given my earlier comments about theory, this made AL more attractive to me: The academic partner could suggest relevant theory, where appropriate to PSTs' problems.

The AL set ends with the group producing an action plan. In Aubusson *et al*.'s (2009) model, the group developed its action plan together because they were working on a common problem, although there could be individual action plans for particular group members if they were working on different parts of the problem. In the model of AL used in PD at Green University, only the person presenting had to come up with ideas about their future action. In Tripp's model, each person came up with a plan based upon reflection on their own critical incidents. Tripp's suggestion is more suitable for this study because I am interested in each of the PSTs developing their practice.

Action

In describing the action part of the process, Aubusson *et al.* (2009:45) refer to 'Kolb's experiential learning cycle' (Kolb, 1984, Appendix G). In the Kolb cycle, the learner moves from concrete experience, to reflective observation, to abstract conceptualisation and then to active experimentation. For me, Kolb presents learning as a cycle because others, such as Dewey, Lewin and Piaget, had described learning in this way, based on a hypothetico-deductive view of the scientific method. Kolb himself appears to view learning as a more fluid process, with learners moving between these four modes, or with different learners using each of these modes to a greater or lesser extent, rather than necessarily moving through them in a particular order. Nevertheless, the action phase of AL appears similar to Kolb's *active experimentation*. Similarly, it would appear to match up with the implementation phase of Tripp's DTC (Fig. 2, p.40). Both Tripp and Kolb imply creation of a plan, followed by implementation of a plan.

When drawing on Tripp in an earlier piece of work, I found it difficult to distinguish this cycle from action research, for example as described by McNiff and Whitehead (2011). As far as AL is concerned, Aubusson *et al*. (2009:16) describe a difference of emphasis where:

> The emphasis of action learning is on the social sharing of personal experiences among a small group, whereas the emphasis of action research is on systematic data collection that is made public.

This element presents a challenge for the current research in two main ways. Firstly, AL is made public via this thesis, rather than being confidential within the group. The other is around feedback, which I discuss in the next section.

Feedback

In AL, the final step is feedback to the AL set. My question is – if it isn't action research, which would involve the systematic collection of data, how do you know if AL has been successful? In Dewey's terms 'the consequences of action must be carefully and discriminatingly observed' (Dewey, 1997:87).

Aubusson et al. (2009) suggest a wide range of evidence that might be used to provide feedback, including:

- Oral feedback from the person who has tried to take the action
- Test data, or other school/class records
- Observations:
    - By peers from within the AL set
    - By the external academic
    - Using an observation schedule
- Written notes or videos/photos of classroom events
- Reflective journals
- Samples of pupils' work
- Pupil feedback:
    - Focus groups
    - Questionnaires

Hence, I am not certain that there is a great deal of difference between AL and action research as they appear to use similar types of evidence. I set out with the intention of enabling PSTs to collect data systematically in schools. However, I anticipated that the data collection may not be systematic, given that PSTs' actions would take place remotely from the university in the school setting, potentially making it difficult to control.

To conclude, the choices of Tripp's DTC model, and of AL, were largely pragmatic ones based on my professional experience working with the Teach First course, and on a course development that was piloted at Green University. However, both have underpinning theories that might support teacher development. In this study, I have brought together AL and the DTC. The AL set effectively becomes Tripp's action inquiry group. Figure 3 shows a diagram of the combined process.

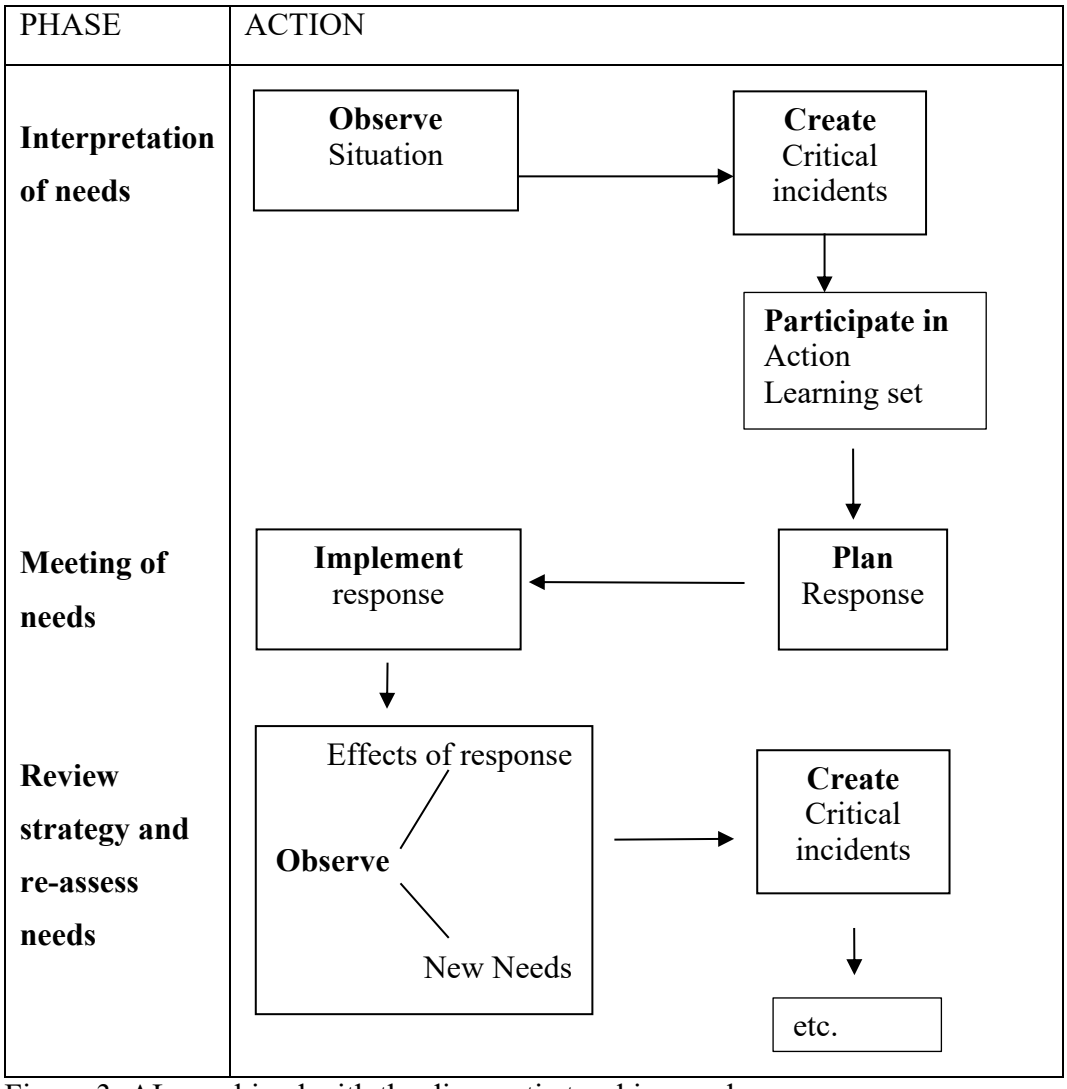

Figure 3: AL combined with the diagnostic teaching cycle

2.5 Theoretical underpinning of the data analysis

This section is in two parts – the first related to the hypothesis that science PSTs are not very reflective; and the second concerning the predominant theme emerging from the data.

In investigating the first of these, I draw upon a colleague's (Paula Zwozdiak-Myers) work on reflective practice. One reason was that since I am completing an Ed.D., researching my professional practice as a science teacher educator, I wished the research to be informed by that of a university in which I was based. I believe that using the university's own research to inform teaching contributes to higher quality university teaching.

Another reason is that Zwozdiak-Myers (2009) has attempted to synthesise concepts underpinning reflective practice in ITE, summarising them in nine dimensions of reflective practice, which I describe in greater detail in section 2.5.1. (See Tab.2, p.48). In so doing, she draws upon Schön's (1983) work on how professionals develop their practice, as well as Dewey's (1933) inquiry-based approach (2.3.1). She cites Hoyle and John (1995) in suggesting that an aim of ITE is to help PSTs to develop into extended professionals, who are able to:

- relate classroom practices to their wider context
- participate in a wide range of professional learning activities
- link theory and practice
- carry out classroom-based research

Drawing upon Stenhouse (1975), she further suggests that an important feature of the extended professional is systematic enquiry into one's own teaching.

Even though Zwozdiak-Myers' research concerned the development of physical education PSTs, it seemed reasonable that the framework might apply to science PSTs. Additionally, the framework is used as a means of describing what it means to be a reflective practitioner in a text commonly used with PSTs in England (Capel, Leask & Turner, 2009).

Within Zwozdiak-Myers' framework, there is a question of what constitutes theory, in linking theory with practice. Here I draw upon Korthagen and Lagerwerf (2001), who describe three levels of teachers' professional learning.

The second part of this section concerns the predominant theme that emerged from the data. Chapter 4 describes the teaching issues raised by participants as they progressed through the programme. In Chapter 6, I include the findings of my thematic analysis of these data. During analysis, it became apparent that participants'

main concern was CBM. In this section, I consider why participants may have had difficulty in developing their CBM. One of the main references is Furlong and Maynard (1995), who suggest a model of stages of development of PSTs, within which they identify developing appropriate professional relationships with pupils as crucial.

2.5.1 Nine dimensions of reflective practice

I use Zwozdiak-Myers' nine dimensions of reflective practice (Zwozdiak-Myers, 2009; 2011; 2012) as a theoretical lens through which the data are analysed in order to judge the reflectivity of participants. Zwozdiak-Myers (2011) defines reflective practice as:

> a disposition to enquiry incorporating the process through which student, early career and experienced teachers structure or restructure actions, beliefs, knowledge and theories that inform teaching for the purpose of professional development (Zwozdiak-Myers, 2011: 83).

She identifies nine dimensions of reflective practice, as summarised in Table 2 (Zwozdiak-Myers, 2011:29).

Dimension	**Description**
1	Study your own teaching for personal development
2	Systematically evaluate your own teaching through classroom research procedures
3	Link theory with your own practice
4	Question your personal theories and beliefs
5	Consider alternative perspectives and possibilities
6	Try out new strategies and ideas
7	Maximise the learning potential of all your pupils
8	Enhance the quality of your own teaching
9	Continue to improve your teaching

Table 2: Dimensions of reflective practice

In this section, I give an overview of the nine dimensions, suggesting how I interpret them in this research. The ninth dimension is not relevant because it applies to

teachers' on-going professional learning throughout their career, beyond ITE, and hence it is omitted.

Dimension 1: Study their own teaching for personal improvement

I suggest that all PSTs in England, regardless of which mode of ITE they are undertaking, will be engaged in studying their teaching to an extent. TS4 states that teachers should 'reflect systematically on the effectiveness of lessons and approaches to teaching' (DfE, 2011:11, Appendix A), so it is a requirement.

My professional practice suggests that at a simple level, PSTs may be asked to consider what went well in their lessons, as well as identifying how they might be improved. Perhaps at a higher level, PSTs are encouraged to consider what their pupils have learned or not learned, and what they might do subsequently to help their pupils progress.

This activity is certainly evaluative, but Zwozdiak-Myers (2012) suggests deeper reflection, involving both cognitive and emotional factors, in order that the person reflecting may improve their teaching and understand themselves better as a teacher. I see the way in which I used AL and the DTC in the teaching intervention as being compatible with this view, as I will explain.

Zwozdiak-Myers (2012) refers to Dewey's (1933) five states of thinking (which are problem, suggestions, reasoning, hypothesis and testing). Arguably, in this process the teacher engages in hypothetico-deductive reasoning, since they think about their teaching problem, implement some plan, and evaluate the success of their plan. There are clear similarities with Tripp's DTC (Fig.2, p.40).

Zwozdiak-Myers (2012) refers also to Schön's reflection-in-action and reflection-on-action (see 2.3.2). Both the analysis of critical incidents and the group discussion in AL sets are intended as a means of bringing about reflection-on-action.

In discussing reflection-on-action, Zwozdiak-Myers also draws upon Korthagen and Vasalos (2005), who emphasise the emotional dimension (How did I feel? How did pupils feel?). Tripp identified the teachers coming to terms with their emotions as a

matter of importance as well (2.4.1), and I have inferred that this was part of the function of his group discussion.

Dimension 2: Systematically evaluate their own teaching through classroom research procedures

Zwozdiak-Myers (2012) envisages PSTs carrying out action research in their classrooms. This activity goes beyond day-to-day processes of evaluating teaching, with PSTs reviewing literature, and planning and implementing a classroom-based enquiry. They consider research ethics, and collect data using methods such as field notes, questionnaires and interviews. They carry out data analysis and consider the validity of their conclusions. Within this project, I planned for the possibility of participants using educational research methods to study their own teaching, as I describe when outlining the intervention in more detail (4.2.1). This is compatible with the *Feedback* element of Action Learning (2.4.2).

Dimension 3: Link theory with your own practice

Zwozdiak-Myers (2012:67) distinguishes between 'espoused theories' and 'theories-in-use', where espoused theories are those based on formal theories of education, or research informed practices, and theories-in-use encompass procedural and tacit knowledge.

To develop the concept of espoused theories further, Orchard and Winch (2015:16) state that:

> We understand 'theory' to mean systematically organised knowledge, whether it is conceptual, empirical or normative, which can be used in teaching to inform professional judgment or action.

Historically, in England, ITE courses included material from the four foundation disciplines of psychology, sociology, philosophy and history of education (Wilkin, 1996). This material might be deemed to be conceptual knowledge, since it may provide an underpinning to discussions of educational issues (Orchard & Winch, 2015). However, Edwards, Gilroy and Hartley (2002:5) suggest that from the 1980s onwards there has been an increasing emphasis on knowledge 'for the practice of teaching', leading to the demise of the disciplines. A possible exception is some material from the field of psychology, particularly that related to how children learn.

An example of a theory from the PD programme (Appendix H) was Vygostky's theory of social learning (1978).

Empirical knowledge is that based on collection of data in research projects. One difficulty in education is that there is a question over the extent to which the findings of educational research are generalisable, i.e. whether they are transferable from one context to another (Winch, 2017). An example of a research evidence based practice that was taught on the programme is AfL (see, for example, Black *et al.*, 2004) which was included in both the PD programme and the science curriculum programme (Appendix I).

In terms of normative theory, Orchard and Winch (2015) point to the inclusion of ethics in Part Two of the TS (DfE, 2011:14), which mentions that teachers should 'maintain high standards of ethics'. However, they suggest that there is a 'gap in teachers' ethical thinking' (Orchard & Winch, 2015:26). My professional experience across a range of ITE courses leads me to suspect that they may be right because, other than discussions of research ethics, I am not certain that a great deal of material about ethics is taught.

The way in which I carry out the analysis for *Dimension 3* results from an issue which emerged from my data, which was that participants made almost no reference to espoused theory. This observation was in contrast with Zwozdiak-Myers' (2009) PE PSTs. Although my research participants made very little reference to formal theories, I suggest that there was an extent to which they were able to articulate theories-in-use. Theories-in-use are personal theories of practice – incorporating 'those patterns of behaviour learned and developed in the day-to-day work of the professional' (Zwozdiak-Myers, 2012:67).

In order to analyse these theories, I draw upon Korthagen and Lagerwerf (2001). They describe a framework with three levels of teachers' professional learning: *Gestalt*, *schema* and *theory*. At the gestalt level, it is argued that the teachers' actions are informed by internal entities (gestalts), and not necessarily by rational thought. Most PSTs went to school themselves, and they may unconsciously teach in ways that are based on their own experiences of being taught. The influences of their role models will be one form of gestalt, along with their own needs, concerns,

preferences and values, for example. The process of schematization is one in which the teacher gains sufficient appropriate experience to enable them to adjust their original gestalt. As a result, 'the person develops a mental framework of concepts and relations between these concepts' (Korthagen & Lagerwerf, 2001:181). At the theory level, the teacher is conscious of an underpinning explanatory model, and the elements of their schema are logically consistent with one another.

Dimension 4: Question your personal theories and beliefs

The fourth dimension is concerned with being able to question preconceptions about education. Zwozdiak-Myers (2012) suggests that PSTs come to their courses with pre-existing ideas, and that these beliefs affect how they behave in the classroom. Furthermore, their ideas may be resistant to change, and may be tacit. Additionally, they may be at odds with what research has to say about effective teaching and learning, and they may fail to take into account ethical considerations. The literature review (2.3.1) revealed that these are some of the concerns about science teaching, since it was suggested that science teachers may default to teaching by transmission, which may not be effective for all pupils.

Zwozdiak-Myers suggests that through questioning their beliefs, PSTs may arrive at positions that are better grounded in evidence. Within this project, questioning of beliefs may be facilitated by the participants using some of Tripp's thinking strategies (Appendix D), such as the Why? Challenge (Socratic questioning) in producing critical incident analyses. Additionally, some of the open-ended questions suggested for the AL set may do so (Appendix F). An example would be 'What judgments are you making about this situation/other person?'.

Aubusson *et al.* (2009:76) envisage 'challenging the things [participants] take for granted' as part of the role of external partner, in this case myself as the course tutor. However, note that in the AL set used in the trial at Green University, the tutor did not take part in the group discussion.

Dimension 5: Consider alternative perspectives and possibilities

The underpinning idea of *Dimension 5* is perhaps that PSTs should develop an attitude of open-mindedness (Zwozdiak-Myers, 2012). In common with the university-schools partnership PGCE courses on which I have worked, Zwozdiak-

Myers assumes a social theory of learning. It is therefore suggested that PSTs can develop multiple perspectives through interactions with others, such as conversations with their mentors; peer observation of teaching (with post-lesson discussion); and seeking feedback from pupils.

Within this project, Tripp's strategies encompass considering alternatives, possibilities and choices in analysis of critical incidents. This mode of reflection may also be supported by some of the open-ended questions suggested, such as 'What could you do differently?' or 'What options are open to you now?' (Appendix F). The AL set itself may enable the PSTs to see their teaching problem from the point of view of another PST, and to see that there are different means of achieving what they want to achieve. However, I think the extent to which the current project addresses seeing matters from the point of view of pupils may be limited. I would expect PSTs to obtain feedback from pupils about what they have learned, but it would be more unusual for PSTs to ask pupils for feedback about their teaching.

Dimension 6: Try out new strategies and ideas

Zwozdiak-Myers (2012) envisages this dimension as involving developing a wider range of teaching strategies during the course of the programme. By developing a repertoire of teaching approaches, teaching is likely to be more effective, since an expert teacher can choose the approach they think will be most suitable for a given pupil or group.

She gives a number of examples of approaches that PSTs might appropriately develop, which include:

- Adopting teaching strategies that actively engage pupils
- Modelling (also referred to as demonstrating or scaffolding) ways of thinking about, or methods of accomplishing, tasks
- Skilful questioning, encouraging thinking
- Giving clear explanations
- Managing group work effectively

In this project, the sixth dimension may be supported by the expectation of the DTC that participants implement a response in the classroom. Participants produce action plans, which may include implementing new teaching strategies.

Dimension 7: Maximise the learning of all your pupils

The emphasis of *Dimension 7* is on meeting the needs of all pupils. Having a concern for pupils' learning is a requirement of ITE programmes because Teachers' Standard 2 is 'Promote good progress and outcomes by pupils' (DfE, 2011:10; Appendix A).

Zwozdiak-Myers (2012) relates *Dimension 7* to the concept of equity (that all children have a right to an education) and hence to differentiation to meet different pupils' needs. In her study with PSTs this was associated with:

> their enhanced knowledge of pupils' ability levels and specific learning needs, greater understanding, awareness and insight of how to promote pupil understanding and accommodate individual pupils; and thinking about what teaching approaches and strategies promote pupil learning and how to plan future lessons. (Zwozdiak-Myers, 2009:254).

This is also a requirement of the programme because TS5 is 'Adapt teaching to the strengths and needs of all pupils' (DfE, 2011:11; Appendix A).

Alongside strategies for personalising learning (i.e. accommodating differences between pupils), Zwozdiak-Myers (2012) places an emphasis on development of teachers' assessment for learning practices. Wiliam (2018) now refers to this as responsive teaching – teaching which responds to feedback the teacher has gathered about what pupils have learned or not learned. Again, this could be linked to TS6 'Make accurate and productive use of assessment', which encompasses 'make use of formative and summative assessment to secure pupils' progress' (DfE, 2011:12; Appendix A).

Since it includes three different aspects of the TS, I suggest that *Dimension 7* is quite wide-ranging.

Dimension 8: Enhance the quality of your own teaching

The emphasis of *Dimension 8* is on PSTs developing 'pedagogic expertise from a research-informed evidence base' and '[high] quality teaching from an international perspective' (Zwozdiak-Myers, 2012:161).

Based on my professional experience as a teacher educator, as well as literature about science teacher development (2.3.1 & 2.3.2), I suggest that a key consideration is development of PSTs' PCK. Shulman (1986:9-10) describes PCK as including:

- Analogies, illustrations, examples, explanations, and demonstrations… the ways of representing and formulating the subject that make it comprehensible to others
- An understanding of… conceptions and preconceptions that students of different ages and backgrounds bring with them
- Knowledge of strategies most likely to be fruitful in reorganising the understanding of learners

For me, developing high quality science teaching involves the development of subject-specific pedagogy. Indeed, Van Driel *et al.* (1998:677) go as far as to suggest that scholars agree that PCK is topic-specific; 'it is to be discerned from knowledge of pedagogy, of educational purposes, and of learner characteristics in a general sense'.

Again, what constitutes effective subject-specific pedagogy in secondary science could be a thesis in itself. I include a calendar showing material taught in the science curriculum element of the programme in the autumn term (Appendix I). I would see this material including subject-specific uses of ICT, where using ICT is an element that Zwozdiak-Myers (2012) includes within *Dimension 8*.

To conclude, in this section I have described the dimensions of reflective practice that I use in the data analysis to investigate the extent to which science PSTs are reflective, which I report in Chapter 5 *Participants' reflective practice*.

2.5.2 Barriers to science PSTs' development

One of my *prima facie* RQs was:

- What are the barriers that science PSTs face during their PGCE?

A number of difficulties with science teaching were identified in the literature review (2.3.1). These aspects of participants' development are considered in Chapter 5, in which I discuss their reflectivity.

In Chapter 6, I present a thematic analysis of the data, looking at teaching issues the participants raised. The predominant concern emerging from the data was CBM.

This fact led me to wonder why participants might find it difficult to develop their CBM, in particular.

That they focused on CBM was not entirely surprising, based on my professional experience, and related literature, both in the UK and internationally. Writing about ITE in the UK in the 1990s, Furlong and Maynard (1995) noted that CBM was a topic of particular importance to PSTs. However, when I first became an ITE tutor in 2010, the then relatively recent Steer Report suggested that behaviour is not too bad in English schools, stating that:

> the great majority of pupils work hard and behave well, and that most schools successfully manage behaviour to create an environment in which learners feel valued, cared for and safe (Steer, 2005:5).

More recently, however, this view has been questioned. Tom Bennett, an advisor to the UK government on behaviour, has stated that 'there is a national problem with pupil behaviour that is not being taken seriously enough' (Rudgard, 2017). He has led working groups which have made recommendations both for ITE (DfE, 2016a) and for school leadership (DfE, 2017) as to how this difficulty could be addressed. There is some evidence from educational research supporting his view. For example, reporting on four studies using a 10-point scale to describe classroom climate (where 10 is the most favourable and 1 is the least) Haydn (2014) suggests that:

> there would appear to be few schools in England where there are no deficits in the working atmosphere in classrooms, and where all classrooms in the school are regularly functioning at levels 9 and 10.

This view is also supported by Jenkins and Ueno (2017:146), who used data from TALIS 2013 to compare classroom climate in different countries. Their analysis tends to suggest that 'teachers in England perceive that there is considerable disruption in their classrooms', and that this may be worse than in many other countries.

Furthermore, Dicke *et al.* (2015:2) note that there appears to be a widespread difficulty for novice teachers internationally, perceiving 'student discipline as their most serious teaching challenge, one that they feel unprepared to cope with'.

In this section, I begin by defining CBM. I then introduce some ideas from literature, which may explain participants' difficulties in developing their CBM practice.

How do I define classroom and behaviour management?

Since participants were on a professional course of training in England, one way to answer this question is in terms of the TS (2011:11; Appendix A). TS7 refers to 'behaviour management', rather than classroom and behaviour management. It encompasses material to do with establishing order ('rules and routines'); as well as having positive interactions between the teacher and pupils ('maintain good relationships', 'use of praise'); and suggests a link between teaching strategies and pupils' behaviour ('using approaches [which] involve and motivate them').

In a review of research asking 'What makes great teaching?', Coe *et al.* (2014:2) define classroom management as:

> A teacher's abilities to make efficient use of lesson time, to coordinate classroom resources and space, and to manage students' behaviour with clear rules that are consistently enforced

This definition adds the notion of managing how the classroom is organised, for example in terms of how the seating is arranged, and how materials for teaching are deployed. Hence classroom and behaviour management (CBM) might be the preferred term.

Educational research tends to refer to 'classroom management', 'behaviour management', and 'discipline', although they are not necessarily used with precisely the same meaning, and there is no overall consensus on a definition (Martin & Sass, 2010:1124). In developing an inventory of teachers' attitudes towards classroom management, Martin, Yin and Baldwin (2008:11) identified three components:

- 'Instructional management' – to do with organising the classroom, including daily routines and deploying materials
- 'People management' – managing relationships with pupils
- 'Behaviour management' – concerning classroom rules, sanctions and rewards

This more holistic view is perhaps more in tune with material about CBM that was taught on the programme. Haydn (2006), which was a core text at Green University, emphasises developing a working atmosphere in the classroom that allows pupils to learn.

Why might science PSTs have difficulty developing their CBM?

In this section, I consider a variety of suggestions as to why PSTs might have difficulty in developing CBM, drawing upon both professional guidance and research literature. Suggestions include:

- Weaknesses in ITE:
    - That courses may not teach PSTs the skills they need
    - That approaches taught may not be sufficiently evidence-based
- Difficulties in establishing appropriate working relationships with pupils

Strategies for CBM are sometimes considered to be teaching skills. Furlong and Maynard (1995:103), for example, refer to material about 'where to stand, how to use their voice and their eyes, how to establish clear rules for the beginning and ends of lessons' as skills. One might attribute PSTs' difficulty in developing these skills to a weakness in ITE. The Carter review of ITE in England (DfE, 2015:6), for example, noted that a survey of headteachers in 2014 suggested:

> The key areas where skill shortfalls were identified [in newly qualified teachers] were classroom management (73% of respondents), subject knowledge (58%) and understanding of pedagogy and child development (56%).

This led to the recommendation:

> Managing pupil behaviour should be included in a framework for ITT content, with an emphasis on the importance of prioritising practical advice throughout programmes. (DfE, 2015:10)

Appendix J shows material suggested for CBM in the core content (DfE, 2016b:19). These recommendations were followed by a report 'Developing Behaviour Management for Initial Teacher Training' (DfE, 2016a), which made highly detailed and specific recommendations, going beyond the core content, including some material about how PSTs might be inducted. In line with Bromfield (2006), we might ask ourselves what can reasonably be achieved on a course that has 12 weeks in university, particularly when there is a range of other recommended core content to be taught.

A particular concern of this ITT behaviour working group (DfE, 2016a:5) was:

> it is imperative that those training in behaviour management are taught by those with highly developed skills and understanding in this area. Evidence of current or recent practice should be preferred.

Bromfield (2006:189) suggests the opposite. She is critical of approaches promoted by policymakers, which she characterises as behaviourist. Behaviourist approaches are based on operant conditioning, via punishment and reward. She argues that 'behaviourist approaches… can over-simplify the nature of behaviour difficulties and stress the importance of discipline and control'. She suggests that, rather, PSTs should learn humanistic approaches (i.e. those that attend to the reasons why people behave as they do), learning about under-pinning theory for CBM, rather than focusing on concrete strategies. She advocates 'behaviour for learning', which focuses on creating conditions in lessons such that pupils can learn, motivating them by taking into account social and emotional aspects of learning (Garner, 2009:140). Arguably, expertise about humanistic approaches could exist in both schools and HEIs. However, Bromfield (2006) suggests that ITE tutors are better placed to help PSTs develop the conceptual and theoretical understandings needed to implement such approaches successfully.

O'Neill and Stephenson (2014) suggest that another potential weakness in preparation for CBM in ITE is that material presented to PSTs is not sufficiently evidence-based. However, the authors base their research on primary teacher education in Australia, and hence this may not be indicative of criticism of courses in England. They carried out an analysis of approaches taught in ITE courses, considering the extent to which the material was research evidence based. They started with a list of 55 strategies for CBM based on their earlier research. They then carried out a literature search for evidence of effectiveness of these strategies, to ascertain the extent to which they were based on empirical research. They then considered the models of CBM taught to PSTs, looking for the frequency with which they included strategies that were supported by research evidence. They found that 18 of the 55 strategies had some empirical evidence for their effectiveness. Of the CBM models used in some of the Australian ITE courses, an approach called Positive Behaviour Intervention and Support (PBIS) included all 18 effective strategies.

I did not find any evidence that PBIS is commonly used in the UK. However, Bromfield (2006) referred to Canter and Canter's (1992) 'Assertive Discipline' scheme having been recommended in a UK government white paper in 1989 (DES & Welsh Office, 1989). Bromfield regards it as a behaviourist approach, and therefore unlikely to be helpful to PSTs. O'Neill and Stephenson (2014) regard assertive discipline as not being supported by research evidence. However, this is a separate issue than whether or not it is behaviourist, since PBIS is a behaviourist approach that was deemed to be research evidence based. O'Neill and Stephenson note that behaviourist approaches tend to lend themselves to empirical research, which might account for the quantity of research evidence found to support some of them.

A further suggestion came from Furlong and Maynard's (1995) study of PSTs' development, which has been influential in informing recommendations for mentoring practices in England (Rice, 2007). Furlong and Maynard (1995) argue that a determining factor in PSTs' success in developing CBM is development of appropriate professional relationships with pupils. They carried out a study in the early 1990s, predominantly (although not exclusively) with primary PGCE students. One of the main outcomes of the project was to describe an overarching progression through a series of stages of development in becoming a teacher, although they do not necessarily suggest that they are moved through in a linear fashion. The stages are *Early Idealism, Personal Survival, Dealing with Difficulties, Hitting a Plateau*, and *Moving On*, as shown in Figure 4 (p.61).

Furlong and Maynard (1995) suggest that PSTs may identify too closely with the pupil when they are in the early idealism stage – that novices tend to see the children as friends. They argue that PSTs need to let go of their early ideals in order to establish their authority. At this stage pupils are seen as the class (and sometimes the enemy). Once professional relationships have been developed, the PST is able to see individual children as learners.

They identify four dimensions of developing appropriate professional relationships with pupils. This is seen to be important because they argue that it underpins the development of their CBM. The four dimensions are summarised in Table 3 (p.62, Furlong & Maynard, 1995:103).

Furling and Maynard (1995) suggest that attaining classroom control may be a particular problem for primary PSTs, since primary schools have an underlying ideology of child-centred-ness. This made it difficult for PSTs to assert their authority and keep professional distance. However, Bromfield (2006:189) researched secondary PSTs and noted that they too 'often begin their courses espousing humanistic views and pupil-centred relationships'.

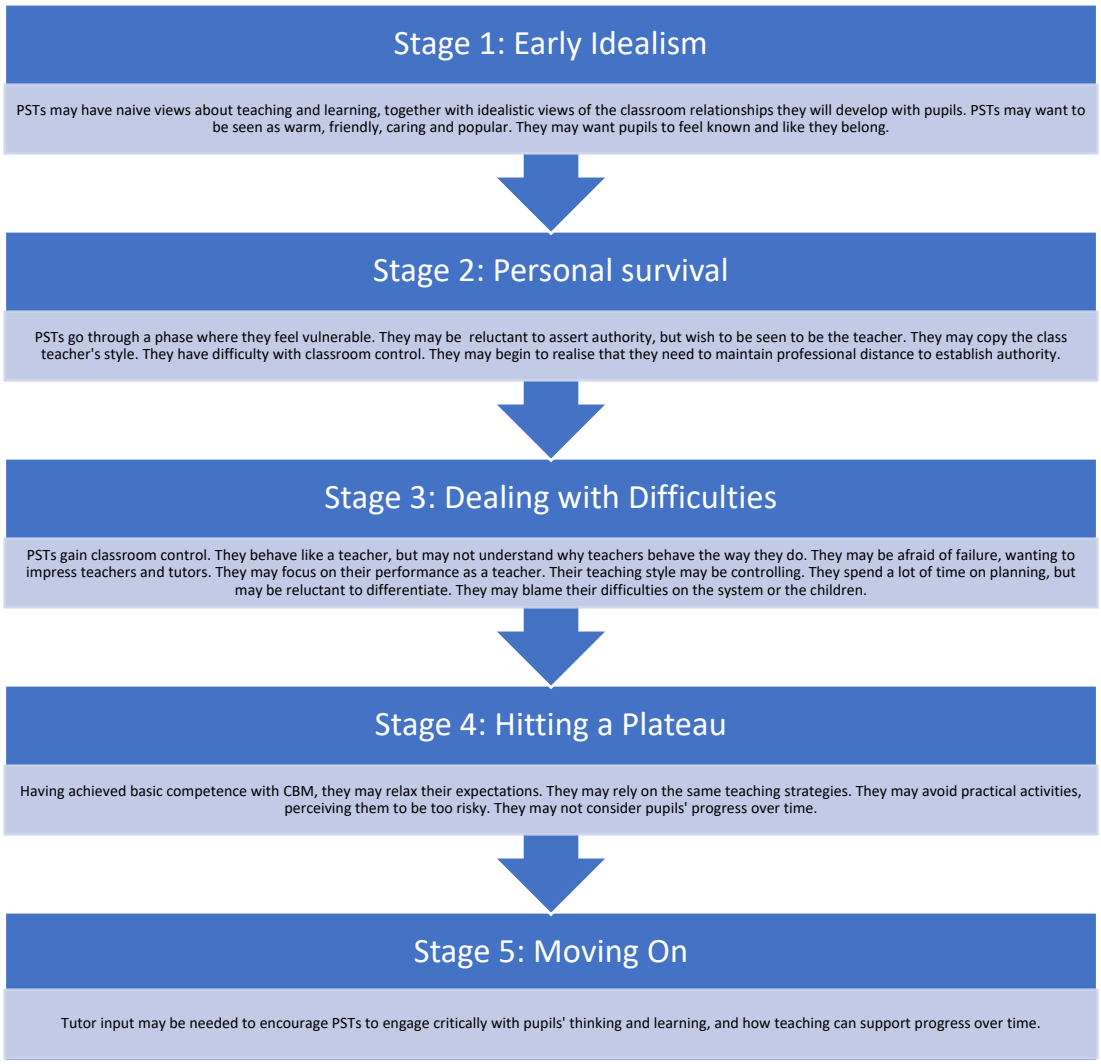

Figure 4: Furlong and Maynard's model of stages of PST development

In terms of managing their feelings, linked with the stages of *Early Idealism* and *Personal Survival*, Furlong and Maynard's (1995:81) PSTs experienced frustration and anger in not being able to match up to their ideals. They noted that, at this stage, 'student teachers appeared to be consumed by a mixture of fear, anger, frustration and exhaustion'. There was a need for them to control these feelings, since class

teachers appeared to be calm and patient, and did not shout. PSTs also had feelings of panic and lack of confidence, which led to them not waiting for quiet before talking to the class, for example.

Dimension	Characterised by, for example:
'Awareness of self – discovering me-as-teacher'	Establishing their authority and commanding respect in a way that fits in with their own personality Setting aside early ideals
'Self-control – managing your feelings'	Remaining calm and positive Overcoming discomfort, e.g. about waiting for quiet
'Self-protection – maintaining your authority'	Developing a range of strategies and a hierarchy of actions Being proactive to prevent disruption
'Satisfaction of self – bringing the personal back in'	Showing they are human Holding pupils in positive regard

Table 3: Four dimensions of developing appropriate working relationships

Furlong and Maynard (1995) suggest that in order to protect themselves, teachers need to develop a professional distance in their relationships with pupils. Rather than developing strategies for pupil management, they found that some PSTs tended towards domination, perhaps out of their feelings of anger and lack of control. However, the strategies they adopted were unsuccessful, being overly confrontational – bringing about rebellious reactions from pupils. They needed to develop strategies leaving room for negotiation; resolving situations without loss of face. PSTs initially lacked strategies for dealing with behaviour, needing to develop a range, or hierarchy, of actions. They also needed to become proactive rather than reactive. It was during the *Dealing with Difficulties* stage that PSTs were able to establish themselves and attain classroom control (Furlong and Maynard, 1995:82).

In a more recent study of PSTs in Canada, Reupert and Woodcock (2010:1265) found some similar patterns of behaviour. Their study suggests that PSTs did not use the whole range of actions available to them, using only 'low level corrective strategies', such as 'moving closer to a student' and 'saying a student's name as a warning'. Overall they were seen to be reactive and corrective, rather than positive and preventative, although they tended to develop preventative strategies later in

their courses. They note that PSTs did not use rewards frequently, and did not feel confident about using rewards, even though they found them helpful when they used them. Reupert and Woodcock speculate that the lack of use of rewards was because PSTs were aware that there is debate about their efficacy.

Furlong and Maynard (1995) suggest that once teachers have established their authority, it is possible for them to enter into relationships with their pupils that are more personal – they are able to show the pupils something of their personal selves. They argue that this enhances teaching because being able to have a joke with classes, for example, helps to bring them along with you. Experienced teachers are able to judge when they need to step back into their professional selves, if there is a danger of becoming too close to pupils, or if they are likely to lose control of classroom behaviour.

A difference between experienced teachers and PSTs was in their attitudes towards dealing with difficult pupils. They suggest that PSTs found it hard to understand them. However, experienced teachers appeared to believe in 'children's ultimate goodness' (Furlong & Maynard, 1995:126). They were keen not to pre-judge their pupils, i.e. they wanted to get to know their pupils for themselves, rather than relying on what others had to say about them; they wanted to understand reasons for pupils' misbehaviour; and they wanted to find something to like about the child.

To conclude, some of the suggestions as to why PSTs find it difficult to develop their CBM are:

- weaknesses in ITE, including not teaching PSTs the skills they need, and making insufficient reference to research evidence
- difficulties in PSTs developing appropriate working relationships with pupils

Overall, I consider that the course at Green University covered material about CBM suggested in the core content. School-based colleagues contribute to the course, both formally in sessions in the university setting, and through mentoring in school-based placements, so arguably PSTs are taught by those with recent and relevant experience. Additionally, I suggest that PSTs on university-schools partnership PGCE courses may benefit from exposure to the differing perspectives of university-based colleagues (whose standpoints may be more humanistic, as Bromfield (2006)

suggests), and school-based colleagues (whose knowledge may be more practical and immediately applicable). Furthermore, I suggest that the course at Green University did not lack research evidence informed material about CBM (Appendix K), including some (e.g. Rogers' Decisive Discipline), which had met O'Neill and Stephenson's (2014) criteria. Hence, in Chapter 6 *Barriers to participants' development*, I discuss participants' progression in relation to Furlong and Maynard's stages of development. This discussion includes consideration of the suggestion that their difficulty may be in developing appropriate working relationships with pupils, drawing upon additional literature, where applicable.

2.6 How have the RQs been modified in light of the literature review?

As noted in the introduction, the prima facie RQs were:

- What are the barriers that physics PSTs face during their PGCE?
- Does action learning help physics PSTs to overcome the barriers they face? If so, in what ways? If not, why not?

The first RQ has been modified to reflect the fact that the group of participants included biology, chemistry, physics and physics with mathematics PSTs:

- What are the barriers that science PSTs face during their PGCE?

Owing to the project adopting some of the strategies of grounded theory some of the modified RQs arose from further reading that was completed after themes began to emerge from the data.

One such question came to light as it became evident that the participants had struggled with developing their CBM practices. This led me to compare their progress in relation to Furlong and Maynard's (1995) stages of development, and to consider whether their difficulty was to do with developing appropriate working relationships with pupils. The relevant RQ and SQ are:

- How does the development of participants' teaching compare with the stages of development of PSTs in the literature?
    - Why might participants have found it difficult to develop CBM?

In the literature review completed prior to data collection, I considered the suggestion that science PSTs have difficulties in being reflective to be a potentially significant barrier to their development on a course that adopts a reflective practitioner model. The teaching intervention included material that was intended to help them to develop as reflective practitioners. An RQ is therefore:

- To what extent are participants reflective?

An SQ is:

  - To what extent is participants' reflectivity related to their success in learning to teach?

Science education literature suggested that science teachers may teach by transmission methods, and that this might limit pupils' progress. This issue can be linked to some of the dimensions of reflective practice, and I explore the extent to which it was demonstrated by the research participants. An SQ is:

  - To what extent are participants wed to transmission modes of teaching?

The teaching intervention used Tripp's model, which was suggested as a method of overcoming the theory-practice divide. However, emerging from the data was the fact that participants made little reference to material they have been taught in the university-based part of the programme. Another SQ is therefore:

  - To what extent are participants linking theory with their practice?

The final RQ was to do with the teaching intervention itself, and has also been modified:

- How well did the teaching intervention work to support participants' development?

Chapter 3. Methodology and methods of the study

3.1 Introduction

In this chapter I introduce the methodology and methods of the study. The problem addressed by the study is that I had observed that science PSTs on a PGCE course in England did less well (on average) on the programme than their peers of other subject specialisms. I wished to understand better the difficulties they had in learning to teach. It was suggested in literature that science PSTs may not be very reflective, and I thought this might explain their difficulty on a course that adopted a reflective practitioner model. Hence I carried out a teaching intervention, which was intended to support development of PSTs' reflectivity. The intervention combined the DTC and AL.

I begin by explaining the study's methodological framework. The study is qualitative and the research design adopted is case study. I give the rationale for this approach, explaining how it is compatible with the ontological and epistemological assumptions outlined in the literature review (2.2). I justify the case study research design, identify the case, and describe the purposes, approaches and processes of the study.

I go on to introduce the research methods. Firstly, I briefly introduce the research setting and research participants, which will be described in greater detail in section 4.2. I then introduce the data collection methods, which were observation (in the form of audio recordings) and documentary methods. Subsequently, I describe the method of data analysis, which was thematic analysis, adopting some of the strategies of grounded theory. Finally, I discuss ethical considerations.

Yin (2014) summarises four tests for quality of research design, as they relate to case study research, which are construct validity, internal validity, external validity, and reliability. Within each section, I consider questions of quality, where relevant, elaborating on the definitions of these terms, and how they relate to this research.

The fact that I was working as a course tutor, and that I was personal tutor for many of the participants, means that this is insider research (Greene, 2014). Strictly speaking, I am not a member of the group being researched in the sense that I was

not a PST at the time of conducting the research. However, I did have prior knowledge of the participants and the course, and was a member of the community in which they were studying, which is another way of defining an insider. During AY2016-17, I moved to a post at another university, and hence for part of the study I might be considered to be only a partial insider. During this period, I remained a student of the university on the Ed.D. programme, so I was also an insider in the sense that I then had my student status in common with my former students. There are implications both methodologically and ethically, which I discuss at relevant points in the chapter.

3.2 The study's methodological framework

This study is qualitative social science research, set within a critical realist paradigm. The study meets several defining characteristics of qualitative research. Firstly, it seeks to understand the process of becoming a science teacher from the point of view of PSTs, i.e. it is concerned with 'understanding people from their own frames of reference' (Taylor, Bogdan & DeVault, 2015:18). It is inductive, in that it seeks to generate theory from data. In this sense, I adopt some of the strategies of grounded theory (Glaser & Strauss, 2008). Additionally, the study looks at the experiences of the participants holistically in 'the situations in which they find themselves' on their PGCE course, revealing their human struggles (Taylor *et al.*, 2015:19). Finally, the study seeks to understand 'what student teachers are confronted by', as suggested by Loughran (2007:1045). Clandinin (1992: 129), refers to PSTs having 'been traditionally silenced'. We might question whether this is still true today. However, writing more recently about a systematic review of research about challenges faced by new science teachers, Davis, Petish and Smithey (2006:607) state that:

> Providing support focused on real challenges is critical in retaining highly qualified new science teachers, but the field lacks a systematic description of these teachers' needs.

Hence, I would argue that the study also meets the criterion of giving a forum to those who may traditionally have been ignored (Taylor *et al.*, 2015).

As set out in more detail in Chapter 2 (2.2.2), critical realism attempts to offer a third way, distinct from positivism and interpretivism. Sayer (2000:19) suggests that:

> compared to positivism and interpretivism, critical realism endorses or is compatible with a relatively wide range of research methods, but it implies

> that the particular choices should depend on the nature of the object of study and what one wants to learn about it.

My aim in this section is therefore to clarify what I am studying and what I want to learn about it, and to justify the approaches adopted. For a critical realist approach, the most important matter is to be able to find out what one wants to find out about the situation being studied, using the methods chosen.

The research design I adopt is case study. In the remainder of this section, I seek to explain why case study is a suitable research design; as well as identifying the nature of the case. I also identify the purposes, approaches and processes of the case study, as suggested by Thomas (2015).

Opie (2004:74) states that 'crucially the focus of a case study is on a real situation, with real people in an environment familiar to the researcher'. Since I was researching an aspect of my own professional practice, working with my own students, at my place of work, this would tend to support the idea that a case study is an appropriate choice of research design. This context, would also meet one of Yin's (2014) criteria for deciding whether or not to use a case study design, which is that case studies look at contemporary (rather than past) situations.

Case studies typically concern a bounded system, for example, one which is bounded personally, spatially and temporally (Ashley, 2012). In this study, the case is the group of research participants, in the context of becoming a science teacher on a university-schools partnership PGCE course in England. The group is bounded in terms of being the group of volunteers who wished to participate; by their location on a particular course of ITE; and by the fact that the time scale of the project was during a single academic year. The fact that this is an in-depth study of this group of participants is also an indicator that case study is a suitable design (Opie, 2004).

The study is a multiple case study because the participants could be considered to be a number of parallel cases (Thomas, 2015). In such a study, it is possible to compare and contrast the different cases, in this instance the experiences of the different PSTs who were participating, during their ITE course. The study is parallel in that the individual PSTs were engaged in the process at the same time, rather than one after another. Whilst the research is bounded by the fact that it was taking place during

one academic year, it is diachronic because data were collected at a number of different times during the year, showing 'change over time' (Thomas, 2015:149).

Case studies are suitable for considering multivariate problems (Ashley, 2012). PSTs' experiences on an ITE programme are undoubtedly multivariate, and there are many variables that cannot be controlled. Arguably, the study looks at a very complex situation, since the PSTs worked in different school placements (each with their own policies and practices), and with different mentors and pupils, teaching different science topics, in different rooms, with different resources available to them. Again, this suggests that case study is a suitable design.

A further factor given by Yin (2014:10) is to consider the RQs. Case studies tend to lend themselves to 'What are…, what can…' questions or 'how much…' questions. Explanatory case studies may also ask 'why'. Hence, the study's RQs and SQs (2.6) can be seen to be consistent with case study research design.

The inspiration for the study was the shortage of physics (or science) teachers, and a concern that they may do less well on ITE programmes than people of other subject backgrounds, coupled with a desire to do something about it. Hence the study is somewhat instrumental - with a practical purpose, e.g. 'with a view to making things better' (Thomas, 2015:98).

Not entirely divorced from the point above, there is a sense in which the case study is evaluative, where evaluative case studies ask 'how well something is working or has worked' (Thomas, 2015:99). PSTs took part in an intervention designed to support their development as teachers, using AL and the DTC. One of the purposes of the case study is to evaluate the success of this intervention.

Evaluative and instrumental purposes could be described as 'contributing to normative theory' (Schwandt & Gales, 2017:345). Through documenting what is, and analysing how it works, it may be possible to make recommendations about what should be.

Another purpose of the case study is explanatory. The literature review suggested that a potential barrier to science PSTs' development is that they are not very

reflective (Malthouse & Roffey-Barentsen, 2014). An explanatory case study is capable of testing theory (Schwandt & Gales, 2018). The study seeks evidence of the extent to which participants are reflective, and considers the relationship between their reflectivity and the development of their teaching.

PSTs' teaching practice in England is assessed against a set of competences mandated by government – the TS (DfE, 2011). In the period in which the research was carried out, university tutors and school-based mentors commonly assessed PSTs' teaching with reference to guidance agreed by UCET and NASBTT (2012). It was a requirement for providers to record a grade of 'outstanding', 'good', or 'requiring improvement' for each PST at the end of their course (DfE, 2012). In the explanatory element of this case study, I hypothesise that greater reflectivity will be associated with better end of course grades.

In an explanatory case study, internal validity is concerned with 'the strength of a cause-effect link' (Yin, 2014:239). Thus, internal validity depends on the extent to which outcomes can be considered to be in line with the hypothesis. To establish internal validity it is also necessary to demonstrate that there is not another explanation for the phenomenon that has been observed.

The study also has an exploratory element, where an exploratory case study has the potential to support hypothesis generation and theory development (Schwandt & Gales, 2018). The research data illustrate the teaching issues of a particular group of PSTs during their ITE course. During the analysis, emerging ideas are linked with prior research, and new ones are formulated using some of the techniques of grounded theory.

Overall, I suggest that elements of the research contribute to the development of normative theory, elements test pre-existing ideas, and elements formulate new ideas.

3.2 The study's methods

In this section, I introduce the study's methods. I include a brief introduction to the context, giving some information about the research setting and the participants, which are explored in greater detail in section 4.2. I then introduce the data

collection methods, which included observation and documentary methods. Subsequently, I introduce the methods of data analysis, which was thematic analysis, adopting some of the strategies of grounded theory. Finally, I outline the ethical considerations, foremost amongst which was the fact that I was course tutor for the participants. Where relevant, I point to questions of quality.

3.2.1 Context and participants

The study took place in the context of my professional practice as a lecturer working with science PSTs on a PGCE programme in England. The timeline of the project is shown in more detail in section 4.2. The general pattern of the PGCE year was:

- initial university-based taught programme (Sep-Oct)
- first teaching placement in school (Oct-Jan)
- second university-based taught programme (Jan-Feb)
- second teaching placement in school (Feb-Jun)

I carried out a teaching intervention with the whole group of 38 PSTs, of whom eight agreed to participate in the research. The details of the intervention are given more fully in section 4.2. The intervention combined two strategies that were designed to support development of PSTs' reflectivity (2.4), which were the DTC (Tripp, 1993) and AL (Bayley, 2015).

Relevant university-based sessions were carried out in October, December, January or February (since different tutor groups were taught on different dates), and April. In each session, PSTs had opportunity to reflect on their teaching issues, by writing critical incident analyses and taking part in AL sets; and to produce an action plan about how they intended to overcome them. Between university sessions, it was intended that PSTs would implement their action plans in the school setting. They were encouraged to keep reflective journals during their placement, as a means of identifying their teaching issues. They then fed back on progress in overcoming their teaching issues at subsequent university sessions, both orally and by writing reviews of their action plans.

All of the 38 science PSTs on the PGCE programme were invited to take part in the research. Of these, eight volunteered to participate, and hence they form the sample

on which the study is based. This may have been one of the advantages of my position as insider-researcher, as I was already known to the PSTs, and hence they may have been more willing to participate than they would have been for an outsider. The participants are introduced in greater detail in section 4.2.2.

3.2.2 Methods of data collection

The data collection tools in the study could be described as falling into two categories, which are observation-based research and documentary methods.

Observation

Observational research entails making systematic recordings, which are then subject to interpretation and analysis (Opie, 2004). The observations that took place in the study were audio recordings of participants' AL sets.

A particular advantage of audio recordings is that 'the transcripts can be used to provide a check against bias or misinterpretation' (Opie, 2004:123). Other advantages of observational research include:

- Enabling the researcher to see the familiar as strange
- Hearing the participants speak for themselves, thus giving you information you may not otherwise have obtained

Generally speaking, a disadvantage of observation may be that the act of being observed changes the behaviour of those being observed. Thus, a relative strength of carrying out audio recordings was that this approach distanced me from the data collection as the course tutor, since I was not present in the room. My presence may have had an even greater influence on the observed than normal, owing to the power imbalance introduced by the fact that I was the course tutor. Note that I gave the PSTs a warning as part of the process of making the research ethical, that there were some things they might say that could affect their place on the PGCE course. This knowledge may have limited their responses to an extent. It is possible that an outsider-researcher may have been able to collect more open responses.

Video recording might have been even better than audio recordings because I could then have seen the participants' facial expressions. This may have made it possible to code for their emotions, as well as making it more likely that I ascribed meaning to what they said correctly. However, I had in the past taught some PGCE students

who were afraid to be video recorded, and overall I considered audio recording to be less intrusive and intimidating.

Two other potential disadvantages of using audio recordings are that the outputs are open to interpretation by the observer, and that the process of transcription is very time-consuming (Opie, 2004). My non-participatory role may have decreased my influence, since I did not interact with the AL sets, and therefore did not ask questions that might lead the participants in a particular direction. On the other hand, my absence limited my ability to ask additional questions that may have enlightened me further as to the social meanings being made by the participants. Being an insider-researcher is a relative strength when interpreting data, however. Interpretation is supported by having a pre-existing knowledge of the setting, and it is supposed that insider-researchers are less likely to stereotype and judge participants than are outsider-researchers (Greene, 2014).

Angrosino (2012) makes a distinction between naturalistic and clinical observations. There was a sense in which the audio recordings in the study were clinical. The groups of research participants were removed from the main group of science PSTs and situated in separate smaller rooms, in order to ensure that high quality audio recordings were obtained. This may have influenced the behaviour of the participants in comparison with other students, who carried out their AL sets within the classroom. The fact that students were given a protocol to follow for AL sets (Appendix E) as well as the accompanying open-ended questions (Appendix F), also tends to make them more clinical in nature, since these materials guided their activity. That said, since the researcher was not present in the room, they may have felt free to express themselves in a way that they may not have done had the researcher been present, which gives the observation a naturalistic element.

Documentary methods

Charmaz (2014:45) makes a distinction between ‘extant’ and ‘elicited’ documents. Extant documents are ones which would have existed had the research not taken place, whereas elicited documents are ones which the researcher introduces as part of the project. The study included both types of documents.

The extant documents in the study included:

- UCAS forms, which had been completed by participants at the point of application to the programme. These provided some autobiographical material.
- Teaching reviews and reports of their progress on the PGCE programme, written by the participants' mentors in their placement school.

Generally speaking, extant documents are considered to be more unobtrusive than elicited documents, and less likely to have been influenced by the researcher. However, note that there are pressures when documents are within institutions. The example Charmaz (2014:49) gave was patients' charts within the hospital: 'such documents also protect the institution and reaffirm its hierarchical order.' In the case of my own data, the teaching reviews and reports:

- Protect the mentor's relationship with the student – they might wish to avoid conflict with the student, and they may be concerned that any negative comments would damage the student's confidence
- Protect the school's relationship with the university partner – they may not wish to be seen to be a poor mentor or poor school placement, since they depend on the university for the supply of NQTs.

Hence there is an extent to which those documents should be interpreted with caution.

I also elicited some documents, which would probably not have been written had I not carried out the intervention:

- Reflective journals
- Written critical incident analysis
- Action plans and reviews of action plans

There is a possibility with such materials that participants will write fiction, to an extent (Opie, 2004). Their writing may reflect the impression they wish to give, rather than something closer to their lived reality. Participants are free to write only what they want to write, and hence may omit some relevant material. The quality of the written material also depends on the research participants' confidence with writing. McCulloch (2012) also points out that there may be a question about

authenticity with materials written by participants, and that the contents are somewhat dependent on their memory of events. Whilst I think it unlikely that a third party would have written reflective journals for them, it is possible that those who were less comfortable with personal writing may have asked for assistance from friends or family.

The data collected are elaborated in section 4.2.1 as some of the data collection methods were used on multiple occasions at different times in the year. A summary of data collected is shown in Appendix L.

3.2.3 Methods of data analysis

I carried out a thematic analysis, adopting some of the strategies of grounded theory. Broadly speaking, I adopted Clarke and Braun's (2014:1-2) approach to thematic analysis, in which the researcher moves back and forth between six phases:

1. Familiarising yourself with the data and identifying items of potential interest
2. Generating initial codes
3. Searching for themes
4. Reviewing potential themes
5. Defining and naming themes
6. Producing the report

Braun and Clarke (2006:6) claim 'theoretical freedom' for thematic analysis, which makes it compatible with a critical realist perspective.

As described earlier (3.2.1) the data collected included a range of written documents, as well as audio recordings. Yin (2014:47) identifies 'the use of multiple sources of evidence' as one tactic which increases construct validity in case study research. This is because it is possible to triangulate between the different sources of data. Construct validity in qualitative research is achieved when:

> the categories that the researchers are using …reflect the way in which the participants actually experience and construe the situations in the research and that they see the situation through the actors' eyes. (Cohen, Manion & Morrison, 2011:189)

Triangulation of data may also contribute to establishing the credibility of insider-research (Greene, 2014).

Owing to the volume of material in the audio recordings, I wrote holistic overviews of what was said rather than verbatim accounts, in the first instance. Throughout the data analysis, I read and re-read the written material, and listened and re-listened to the audio recordings to familiarise myself with the data. This included returning to the audio recordings to make full transcriptions of some elements that were not originally transcribed verbatim, in order to check participants' meanings. A database of the written material may be inspected by readers of this thesis upon request, which increases reliability (Yin, 2014). In case study research, reliability is concerned with the extent to which another researcher, following the same procedures, would arrive at the same conclusions. Keeping a database provides opportunity for others to inspect and audit the documents, which would allow checking if someone wished to do so (Yin, 2014).

Content analysis is an appropriate approach for large sets of written data (Grbich, 2007). Hence this was the approach adopted to generate initial codes from the reflective journals, since these were the largest written data sets, as well as the critical incident analyses and action plans.

Since the first of my prima facie RQs was 'What are the barriers that physics (or science) PSTs face during their PGCE?', the coding and categorising process focused on items that I considered to be teaching issues or concerns raised by the participants. To this extent, I had a preconceived idea of what I was looking for, although the coding did not use a 'prior protocol' (Grbich, 2007:112), since there had not been a great deal of information in the initial literature review indicating what science PSTs' teaching issues might be. I did not have an entirely open mind, where I might have asked questions such as 'What is this data a study of?' (Thornberg, 2012:86), and hence this was not a grounded theory approach in this regard. I note, however, that my preconceptions were based on my professional experience. One might say that I had used 'middle-range coding' (Urquhart, 2012:39), since it was neither entirely bottom-up nor top-down.

The introduction of preconceptions based on professional experiences may be seen to be problematic for an insider-researcher (Greene, 2014). There is a possibility of projecting one's existing beliefs onto the data analysis, which may introduce bias.

Conversely, it may be seen as a strength, since one's prior knowledge may be helpful in perceiving the situation more clearly.

The frequencies of each type of teaching issue were enumerated. Understandably, this was a somewhat subjective process, since it is likely that the particular terms used to code the text were informed by my professional experiences working with PSTs. However, this was done in a consistent way by following the approach suggested by Clarke and Braun (2014). Another factor that may have mitigated against bias, and helped to establish credibility (Greene, 2014) was regular meetings with my supervisors, which facilitated scrutiny by those a little less close to the research context.

The overviews and transcribed material from audio recordings were developed into narrative accounts of each of the AL sets. Patterns emerging within and across AL sets were identified.

Subsequently, profiles of each participant were written, producing a chronological narrative describing their pathway through the programme, drawing on all the available data. Putting information in chronological order is an analytic strategy that is used in case study research (Yin, 2014). This process had several outcomes. One was that it enabled me to refine the themes emerging from the data. The profiles of the participants were also reflective accounts, in which I wrote down my thoughts about the data. Interjections within the text, such as these, are sometimes described as theoretical memos. Writing theoretical memos is a strategy that was first suggested by Glaser (1978) as part of grounded theory. However, it has been used in qualitative research more generally (Urquhart, 2012).

Within grounded theory, memos are regarded as being essential to quality of research (Birks & Mills, 2015). They contribute to quality because researchers are encouraged to write freely, which supports creativity (Urquhart, 2012) and they also enable the researcher to keep track of their thought processes about the research (Birks & Mills, 2015). 'Thick description' and 'detailed note-taking' (Greene, 2014:7) also contribute to transferability, which is one technique that may contribute to trustworthiness of insider-research.

At the next level of analysis I took two approaches, both of which are compatible with case study research, according to Yin (2014). The first strategy was to explore the conjecture that science PSTs are not very reflective. This entailed a deductive approach, looking at the data through an existing theoretical lens. The second strategy concerned themes that emerged from the data (and hence the link with the strategies of grounded theory), thus being a more inductive approach. At this stage, I referred back to literature, which enabled me to carry out further analysis of the data using a relevant theoretical framework. Again, these are the approaches of thematic analysis (Aronson, 1995). The approaches are elaborated in the relevant data analysis chapters (Ch.5-7).

3.2.4 Ethical considerations

The ethical considerations for the research were developed based on the regulations of Green University, and were in line with the department's education research committee guidelines, informed by a seminar (Russell, 2015). I am confident that the research was carried out at least in line with British Educational Research Association guidelines (BERA, 2018) and in some areas may have gone beyond these expectations, as I will explain. I have adopted some of the headings used in the BERA guidelines to address my responsibilities to participants:

- Consent
- Right to withdraw
- Harm arising from participation in research
- Privacy and data storage
- Disclosure

Consent

> An important consideration is the extent to which a researcher's reflective research into their own practice impinges upon others – for example, in the case of power relationships arising from the dual roles of teacher/ lecturer/manager and researcher, and their impact on students (BERA, 2018:13)

One of the main ethical considerations was that the participants were my own students.

At the recruitment stage, it was made clear to them that the decision to participate or not to participate would have no bearing on their treatment on the PGCE course. This was explained at the point of requesting the students' informed consent to take part. In reality, I think this matter is not all that straightforward. As a PGCE tutor, I have a number of different responsibilities, which may compete with one another. These include responsibilities to the student in terms of ensuring that they receive high quality ITE on the programme, giving them the opportunity to become good science teachers, and to provide evidence of meeting the TS (2011); a responsibility to the teaching profession as a gatekeeper; a responsibility to protect the reputation of the university; and a responsibility to school partners as key contributors to the university-schools partnership PGCE programme, and as future employers of many of the participants. To a large extent, though, data analysis took place after the PGCE course had been concluded, and hence the possibility of anything that was disclosed in participants' data affecting their progress on the course was not great. However, I acknowledge that a negative effect on working relationships is a possible repercussion of insider research (Greene, 2014).

The research was explained to all the science PSTs in an introductory taught session about reflective practice. They were given an information sheet and consent form (Appendix M). They were invited to hand in the signed consent form to my supervisor, which meant that they were not under any pressure to respond immediately.

Participants were made aware that I may produce papers as well as a thesis, because they should know what may happen with the contributions that they provide.

As part of the DTC (Tripp, 1993), I suggested that participants may wish to collect data in their placement schools, to provide evidence of improving (or not improving) on the areas for development they identified. I provided materials for the participants to obtain the consent of the headteacher (a gatekeeper), as well as informed consent of pupils and their parents as needed (Appendix N). In the event, none of the participants collected data of this nature.

Right to withdraw

Participants were given the right to withdraw their data. Information about how to withdraw was provided, including the contact details of a third party (my main supervisor) in recognition of the fact that they might not feel able to tell their tutor. Because participants would be taking part in a recorded group discussion activity, it was explained to them in advance that it may not always be possible to tell what was said by whom, and hence it might not be possible for them to withdraw all aspects of their contribution.

Harm arising from participation in research

Because AL sets asked participants to discuss teaching issues, there was some possibility of emotional and psychological difficulties being raised. To mitigate this situation, participants were informed about how to access university support services, which include counselling services.

The BERA guidelines ask researchers to consider the impact of not using interventions with control groups (BERA, 2018). Strictly speaking, my research was not a quasi-experimental study making comparisons between a group of research participants and a control group. Nevertheless, I took the decision to make the intervention available to all science PSTs, regardless of whether or not they had chosen to participate in the research. In this regard the study went beyond BERA's expectations. All science PSTs were included in taught sessions about reflective practice, and had opportunities to take part in writing reflective journals, in AL sets, and in writing action plans to develop their practice. The only difference in treatment of the group of research participants was that their AL sets were recorded, with their consent, and that these discussions took place in a separate room.

In the initial information, PSTs were made aware that there was the possibility that AL sets would need to take place outside of the time of their usual taught sessions. Additionally, writing reflective journals would be completed in addition to the normal requirements of the course. It was important that they were informed of this in advance as their decision to participate had implications for their workload. In reality, completion of the reflective journals was voluntary, as was participation in the final AL set, which was the only one to take place outside normal working hours. Overall, I do not think they were disadvantaged.

Privacy and data storage

In order to provide anonymity, participants were invited to choose their own pseudonyms, which are the names used throughout this thesis. Details of the university attended, and any schools, pupils and colleagues (university tutors or school-based mentors) that were named in the raw data have also been anonymised.

The research complied with data protection, as described by BERA (2018). All material collected was stored securely. Paper materials, such as reflective journals and action plans were stored in the researcher's office. Electronic copies of materials, including scans of paper materials and audio files were kept on an encrypted drive. In line with university policy, data will be stored for 10 years.

Disclosure

Because participants were asked to take part in audio recordings of their teaching issues, to keep reflective journals, to write critical incidents and to analyse them to reveal underlying assumptions, there was the possibility of them expressing thoughts about their attitudes and values which may raise questions about their fitness to practice as teachers. If I had a serious concern about a participant, it would be necessary for me to take action, in my role as course tutor. This might include initiating the university process for assessing professional suitability, and hence might threaten their successful completion of the PGCE. In order to pass the PGCE, students must demonstrate that their professional practice meets Part Two of the TS, which deals with teachers' personal and professional conduct (DfE, 2011; Appendix A). Participants were warned about this possibility and given the option of not disclosing parts of their file. It was also explained to them that this may be a reason why they might wish to withdraw from the research project. This element of the process had the potential to cause difficulties with working relationships with PSTs, given my position as insider-researcher.

3.3 Summary and outline of chapters to follow

To summarise, the study is qualitative social science research, with a case study research design. Case study is an appropriate design, particularly in light of the fact that it is a bounded, in-depth study. It is a multiple case study, where the cases under consideration are the research participants undertaking a PGCE on a programme, on

which I was a course tutor. The data collection methods are observation and documentary methods. The method of data analysis is thematic analysis, adopting some of the strategies of grounded theory. The strategies concerned are content analysis and writing theoretical memos. Ethical considerations are in line with the recommendations of BERA (2018), the most significant of which is the power imbalance introduced by the fact that I was the students' tutor.

That said, being an insider-researcher also has some benefits, such as perhaps increasing the likelihood of the PSTs participating in the research; gaining insights that an outsider-researcher may not have seen; and tending to stereotype and judge participants less. However, an insider-researcher does need to take care that their preconceptions do not compromise criticality (Greene, 2014).

In Chapter 4, I describe the setting and research participants in greater detail, as well as setting out the procedures that were followed to collect the data. In Chapters 5, 6, and 7, I present outcomes of the data analysis. Each chapter is concerned with different aspects of the case study – answering different RQs. Throughout Chapters 5 to 7, I refer back to the relevant material in the research database in order to construct a 'chain of evidence' (Yin, 2014:128) that helps to establish trustworthiness of the study's findings.

Chapter 4. Context, fieldwork activities, participants and themes

4.1 Introduction

In this chapter, I begin by describing how I used AL and the DTC in my teaching, and how data were collected. Subsequently, I introduce the participants and introduce the main themes identified in the data: CBM, reflectivity, science subject-specific difficulties, and participants' progression.

Whilst this introductory material is largely descriptive, I was keen to include it in this form because Clandinin (1992:129) had suggested that PSTs may be the sort of participants who 'have been traditionally silenced', and that there was a risk of the researcher putting words in the participant's mouth. I hope to allow the story of the participants' experiences on the PGCE programme to be told, as far as we are aware of them from the data, with more interpretative material to follow in the data analysis chapters (chapters 5 to 7). I did not wish to impose my own ideas on what they had said at this stage, to the extent that this is possible to do. That said, I aim to include a commentary in the form of a reflective account.

4.2 Context, fieldwork activities, and participants

The first part of this section is a chronological account of the teaching intervention, together with information recruitment and data collection. A timeline of the research is shown in Figure 5 (p.84). Subsequently, I introduce each of the eight research participants.

4.2.1 Context and fieldwork activities

When the research began (October 2016), I was employed as a lecturer at Green University, working with science PSTs on a university-schools partnership PGCE course. In AY2015-16, the course had piloted AL with all PSTs. I planned to use it, together with Tripp's (1993) DTC, with the intention of supporting the development of science PSTs. The course had recruited 38 science PSTs, with a mixture of

subject specialisms, which included biology, chemistry, physics, and physics with mathematics.

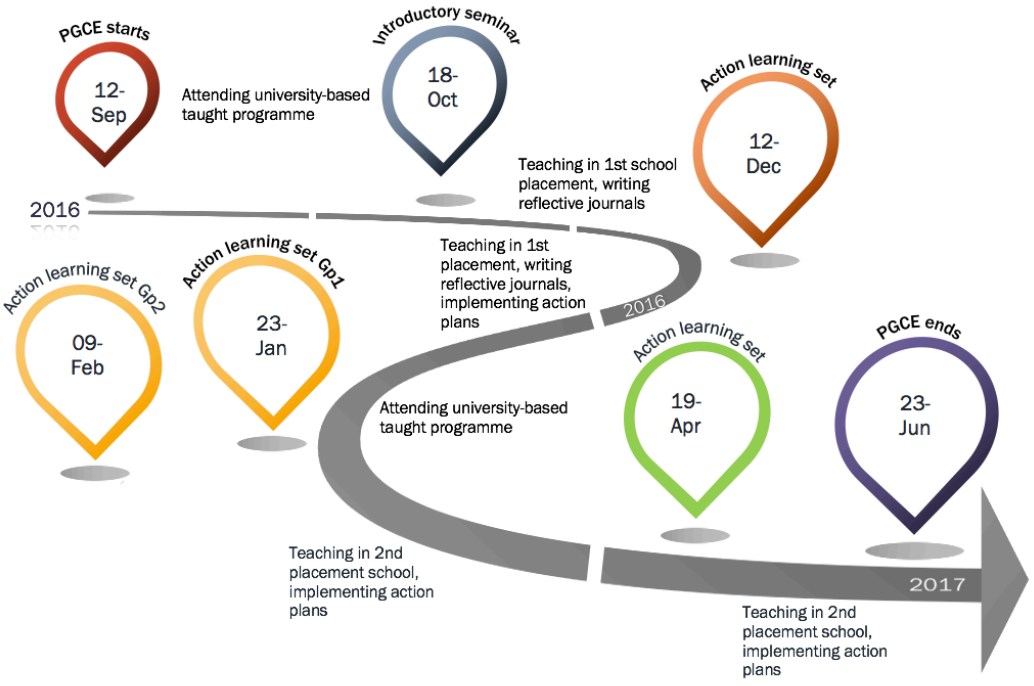

Figure 5: Research timeline

18 October 2016: Introductory seminar 'Critical incidents in teaching and action learning'

This seminar was taught in October half-term, prior to PSTs going full-time into their first school placement. They had spent 4 days in school before half-term, so they may already have had some ideas about their development needs. After half-term, they would be in school full-time, and expected to plan and teach lessons over the next few weeks.

I introduced them to Tripp's DTC (Tripp, 1993). The rationale I gave was that it could take PSTs beyond simply evaluating lessons, and making judgments about what has been learned or not learned, enabling them to develop their professional judgment.

I then introduced the PSTs to keeping a reflective journal as a source of material to analyse, with two suggestions as to how to approach this task (Appendices O and P). The resources were adapted from courses I worked on previously. Conscious of the

fact that PSTs find the PGCE very intensive, I wanted to offer them a simple option to encourage journal writing to take place.

I introduced the PSTs to critical incidents, referring to examples from Tripp (1993). I then introduced the four types of judgment Tripp suggested – practical, diagnostic, reflective and critical (Appendix C). I also introduced Tripp's kinds of analysis, giving two examples of thinking strategies, which were 'reversal' and 'The why? Challenge' (Tripp, 1993:45 and 46, respectively, Appendix D). PSTs then discussed and evaluated an exemplar lesson evaluation, in which a PST had tried to apply Tripp's model to her work.

PSTs then wrote their own critical incident analysis using one of Tripp's strategies. The focus was a teaching issue, a problem, or a challenge – i.e. something that concerned them about their forthcoming school placement. Aware (from professional experience) that science PSTs may find writing prose to be challenging, they were allowed to discuss their analysis with a partner before writing.

We then moved on to AL. The materials were adapted from those used the previous year in the PD programme, which were from a speaker at the annual mentor conference (Bayley, 2015). We discussed ground rules to maintain confidentiality (Appendix Q).

PSTs then split up into groups of 4-8 and carried out an AL set (Appendix E). They were provided with examples of open-ended questions (Appendix F). Action is needed to make this discussion into AL. I planned to achieve this by PSTs writing an action plan, to implement in school, reporting back at a later stage. The implementation phase is where I see this to be aligned with Tripp's DTC (Tripp, 1993). I showed the PSTs an example of an NQT's action plan (Belfast Education and Library Board, 2016 – Appendix R) and we discussed its key features, such as success criteria.

PSTs then wrote action plans based on their teaching issues. To close the session, I used the same plenary as in the pilot:

> Now spend time gaining feedback from the groups about how the action learning process worked for them so far. Identify the key factors which lead to the process being most effective and successful. Explore how regular use

> of the process may influence/support their professional development. What mind-sets and problem-solving strategies might this process develop in trainees? You may wish to discuss Carol Dweck's (2008) 'fixed' and 'growth' mind-sets in relation to this process.

Immediately after the seminar I introduced my research project, referring to the information sheet developed in the ethical approval process (Appendix M). Information sheets and consent forms were distributed. If PSTs wished to participate then they were invited to complete and hand in the consent form in a session three days later.

Eight PSTs volunteered to take part. They were invited to hand in their action plans.

12 December 2016: 2nd Taught seminar: Action learning revisited
PSTs had been working full-time in school, and returned to the university for one day in the last week of term.

The rationale was that becoming a teacher involves personal and professional change or development, and this process is thought to be supported by reflection (2.4.2). I contrasted a technical approach (How am I going to do this?) and a professional approach (How am I going to decide what I ought to do, and how can I justify why I ought to do it?) I reminded them of the material I had introduced in October.

I asked PSTs to think of a teaching issue they faced during placement, and to write down a description of it. They then attempted to apply one of Tripp's (1993) approaches to critical incident analysis, e.g. reversal. They were further asked to reflect on what their writing revealed. Research participants were asked to hand in their written work.

I then reminded the PSTs about AL sets, including the need for confidentiality. The AL set was modified as follows:

- I added a feedback step, in which PSTs talked about their progress in tackling their teaching issue from October.
- Every member of the AL set would present their issue and be questioned by the other members, rather than just one of them.

- To ensure that the audio recordings were successful, the participants carried out AL sets in separate rooms, working in two small groups.

Once AL sets concluded, I returned to the idea of action planning. I introduced some suggestions about what might count as sources of evidence of having overcome the issue that had been identified (Appendix S). There were ethical considerations associated with participants collecting data in schools. I gave them information about obtaining the head-teacher's approval, as well as the consent of learners and their parents or carers (Appendix N).

The session concluded with a similar plenary to the previous seminar (p.85-6). I collected material from research participants, including reflective journals, critical incident analyses, and action plans.

23 January or 9 February 2017: Group tutorial: 'Reflective writing and action learning'

PSTs worked full-time in their schools for about three weeks in January. They then returned to the university for several weeks. Participants were in two different tutor groups, so the seminar took place on different days. The first activity was to complete the evaluation and reflection sections on their December action plans.

From reflecting on critical incident analyses produced in the earlier session, I wished to support PSTs in developing reflective writing. I sent them Moon's 'Samples of reflective writing' (Moon, 2013:192-195) as pre-reading. We discussed the features of reflective writing.

PSTs then created a critical incident based on an issue from the last few weeks of teaching in their first school placement. I used Moon's 'Generic framework for reflective writing' (Moon, 2013:214-216) to provide further scaffolding.

We then repeated the AL set. Because I had started to listen to the previous audio recordings I was aware that some participants found it difficult to stick to asking open questions. Hence, I underlined the need to keep the questioning open, in order to encourage the presenter to think and reflect. Because the two groups of science PSTs were taught on two different days, one AL set had six participants and one had

only two. This was not ideal, as the original plan had been to have groups of four to six.

Once the AL sets concluded, PSTs again wrote action plans. I collected in participants' written work, including updated action plans from December, critical incident analyses, new action plans, reflective journals. I also collected material about research ethics, and obtained copies of the school mentor's report on their teaching at the end of first placement, where available. For some PSTs the interim teaching review from part-way through the placement was also available.

19 April 2017: Twilight seminar: 'Developing reflective practice using critical incident analysis and action learning'

I left my post at Green University in February. I was able to negotiate an opportunity to carry out one further session. An AL set was carried out as a twilight session, after a normal university-based PGCE day. Four participants were able to attend, joined by two other PSTs. Material presented by the additional PSTs was not transcribed and was not used as part of the research data. I have anonymised their questions in transcriptions of AL sets for research participants. Prior to the AL set, research participants reviewed their previous action plans, where available. Owing to the time constraints imposed, we did not carry out the task of writing critical incident analyses. Three participants contributed written action plans based on the AL set.

End of PGCE course – June

I emailed the research participants, asking for their end of course report. Three of the participants responded positively.

A summary of the teaching intervention and a summary of data collected are shown in Appendices T and M, respectively.

4.2.2 The research participants

There were eight participants, who are referred to by their chosen pseudonyms: CM, Connor, Dean, Emily, Kathryn, Paul, Rachael, and Zoe. A brief introduction to each participant is given below.

CM was a career changer, who had worked in engineering for a considerable period, and was doing the physics with mathematics PGCE. From my knowledge as course tutor, I am aware that he had pre-course experience in schools as a Science Ambassador.

Connor progressed onto the biology PGCE course immediately after his undergraduate degree in ecology. He had been educated overseas beforehand. Whilst in high school, he had assisted his science teacher with various tasks, including marking, and setting up and clearing away chemicals. However, he had observed biology lessons in a state school in England for only one day. He had also taken an undergraduate module in science communication, which included some teaching in a sixth form college.

Dean started the chemistry PGCE after working for 18 months as a science technician in a secondary school. His undergraduate degree was in biochemistry. He also had two years' experience of working with young people in a Scout Group.

Emily progressed straight onto the biology PGCE after completing her undergraduate studies in zoology. From her UCAS form, she appeared not to have gained experience of observing science lessons in a UK school (as an adult) prior to applying for ITE. On her UCAS form, she referred to acting as a teaching assistant (TA) for pupils in Year 7 to 10 whilst shadowing a biology teacher when she had been a sixth form student, as well as 'organising engaging activities for local children' whilst on two voluntary projects renovating primary schools overseas.

Kathryn was a mature entrant to teaching. She had a range of work experience, including in financial services and retail. She then undertook a degree in biochemistry as a mature student, taking up the PGCE in chemistry upon graduation. She had carried out outreach activities with primary and secondary children during her studies, and had also observed secondary science lessons for five days.

Paul progressed onto the chemistry PGCE course from his undergraduate degree in chemistry. He had a relatively high level of experience of working with young people prior to starting ITE, having worked with them at a summer camp in the USA for three years. However, he had not carried out any observation in schools.

Rachael was a mature entrant to the profession, doing the physics PGCE. Her first degree was in combined science, so she completed both A Level Physics and a physics subject knowledge enhancement course before taking up her place. Immediately prior to entering ITE she had worked for a considerable period as a TA in a secondary school. She had a range of other work experience, including care work, and other experience of working with children, such as summer camps in the USA.

Zoe was a recent graduate whose subject specialism was biology. Her first degree was in molecular biology and genetics. Prior to the PGCE she spent a year teaching children with special educational needs and disabilities in a complex needs school.

4.3 Themes identified in the data

In this section, I present some of the themes identified in the data. It is not possible to present all the material about each participant owing to the volume of data collected. In this section, I give an overview of major themes, which are explored further in subsequent chapters. In each section, I illustrate the theme with examples from participants' accounts. The themes I consider are CBM, reflectivity, science subject-specific issues and participant's progression.

4.3.1 Classroom and behaviour management

CBM emerged as a teaching issue for the majority of participants from the beginning. Examples in this section exemplify commonalities between participants, including dealing with low-level disruption, developing a rapport with pupils, and a lack of reference to material from the taught programme.

Low-level disruption

Throughout their first school placement, many of the participants brought up teaching issues in which they expressed concern about dealing with low-level disruption. Zoe's data exemplify this issue. In Zoe's reflective journal (Oct-Dec) the category of teaching issue that arose most frequently was CBM, with 11 of 14 issues being in that group. The issue she mentioned most frequently was the need to project her voice (n=3), for example:

> They [the pupils] were occasionally chatty, especially during the register, which was reflected in feedback to work on voice projection and making a presence in the classroom.

Zoe described pupils talking while she was talking, and mentioned strategies for dealing with this, which were:

- 'Creating an expectations slide'
- 'Using the strike board' [implementation of the school behaviour policy]
- 'Waiting and insisting on silence before I speak'

She chose to talk about this issue in the December AL set:

> Okay, so my critical incident is getting the attention of the class – a chatty group. Cos I've got a quiet voice. Not very good at projecting my voice yet across a big room – cos my room's really wide for most of my lessons. And I can wait for quiet, which works really well, and they're really lovely children, but it takes ages. I'm standing feeling like we're not doing anything productive in the time cos I'm just stood at the front waiting for you guys to be quiet.

She had also tried a 3-2-1 countdown, but found it sometimes took longer than others. She said writing minutes on the board (to keep the class behind at the end) had not worked, and she was reluctant to punish the whole class when not everyone was talking. The other participants suggested some further strategies:

- 'Stop them all and give them a bollocking' (Connor)
- CM recounted that after a lesson had gone badly he introduced himself to the class, giving them some background information about himself, before setting ground rules
- Using a raised voice to say 'Year 9' or 'Year 10' after the 3-2-1 countdown if pupils were still not quiet, 'and then I have gone on to shout if I need to' (Dean)
- Learning the pupils' names, so that you can apply sanctions (CM)
- Standing next to a pupil who was turning round and talking (Dean)
- Embarrassing a pupil, for example 'Okay, a few minutes ago so-and-so you were talking, now what was that about?' And if it's not about the lesson, so 'oh, go on, what were you talking about?' (Dean)
- Having 'your regular way to get the class quiet, and then a second one which is more authoritative and a bit more serious, so you can let them know that this is too much now and we need to get on with the lesson' (Paul)

Zoe herself said that she had a successful strategy with her Year 9s, which she thought worked because they were eager to please:

> What works really well is telling them how much you were looking forward to their lesson, and how much you wanna get on with this, and how you're having great, great times with them, but there's a few letting you down because of that.

In conclusion, Zoe decided that she needed to make her expectations clear, as well as having clear sanctions. She thought she needed to develop a second step for when things got more serious. On the action plan she clarified this as planning to use the 'strike board' (recording a tally against the name of pupils who misbehave).

Several participants appeared not to be following through with sanctions. CM had similar difficulties to Zoe with low-level disruption. He, too, had some ideas about how to deal with it, which were to use the school behaviour policy, give warnings, to give detentions, or to send a pupil out of the room. However, he had not yet done it. In CM's words (December AL set):

> It's just having that courage to have that first blood, which I'm, I'm getting better at it, I'm getting stronger about it, I'm getting to the point where they're actually seeing that I'm – they're seeing 'Oh this guy is actually the teacher'. But it's just, having that confidence, I guess just having the balls to say 'Right, this is it, I am your teacher, this is my classroom, get out of my classroom.'

Participants also seemed to be somewhat reticent about rewarding pupils. For example, in his AL set in January, Dean's issue was a quiet class where pupils were not willing to answer questions orally. CM suggested using rewards, such as sweets and merit marks, as ways of persuading pupils to participate. Dean responded by saying that 'Year 10 don't give a shit about merit marks'.

Developing a rapport with pupils

Perhaps the underlying question was one of developing a good rapport with pupils, which is exemplified in Paul's January AL set. Paul found teaching his Year 10 class challenging, finding it hard to be consistent because 'so many little things pop up all around the classroom'. He recounted an incident with a specific pupil, which had ended with her calling him a very rude word, after which she was internally excluded by the school:

> We'd been doing an assessment that lesson, so we'd been using the green pens. At the end of the lesson I was asking everyone to bring the green pens back into the tray. I looked and saw this pupil throw her pen on the floor, and she caught eyes with me and I thought 'I can't let her get away with that'. So I said she needed to pick up the pen. But there was another green pen on the desk behind her and she gave me that one. 'No you need to pick up the original green pen that I saw you throw on the floor.' And she was defiant and wasn't doing it at the start and it was getting towards the end of the lesson when I should be releasing pupils. ' I'm not going to release everyone until you pick up that green pen.' And you could see that she was quite angry, but she did pick it up, and then as she left the room she said the rude thing.

Paul said he thought that Year 7 and 8 were more engaged. He had a good working relationship with his Year 7 and 8 classes, but did not know how he had created it, which made it hard for him to know how to win over the Year 10 pupils. He commented:

> Having good relationships with the kids makes it more fun for them and I think it makes it more fun for you as well. I've got a Year 7 class that I get on really well with and I had a metre rule and I did this Gandalf thing 'You shall not pass'. They were laughing, I was laughing, that was one of my favourite lessons cos we all enjoyed it. But you know I never had any moments like that with the more challenging Year 10 class. I think if I'm having fun and they're having fun that's going to facilitate learning to a higher level.

Lack of reference to the taught programme

Another observation about participants' discussions about CBM was the lack of reference to material taught on the course. In the December AL set, for example, Connor was dealing with a pupil who was refusing to do his work. Connor introduced the issue as follows:

> So mine is basically - it's only happened a couple of times - but it's something that's got to me. When a kid, like, isn't doing what I want them to do. Like for example, um, doing a laptop lesson where we're researching echoes and stuff. This kid gets out a laptop. He says 'Oh, sir, it's not working.' I go over and check and it says the battery is dead. 'Okay, well put it back and get a new one.' He says 'no'. And that goes on for a bit and I basically just go through the behaviour policy and everything but he's not doing what he needs to do, he's not getting on with his work. Everyone else is not doing their work now because I have to deal with him. And then he just shut down.

The pupil's refusal had resulted in Connor sending him out of the room to his mentor, which was the highest level of action he could take. Connor felt bad about this – he found the pupil's passive resistance difficult, and did not feel as though the pupil deserved that punishment:

> Cos when they're like getting in your face and being angry or whatever, you can, you know, deal with that accordingly, but when they're just like sat there not looking at you and just sort of not doing anything that's like what do you do?

The group suggested possible solutions, which included:

- Giving the pupil a choice, of the type 'Either you can do this now or you can come back at lunch time' (suggested by CM), which teachers might call a forced choice.
- Giving better instructions at the beginning about what to do if things go wrong (e.g. the laptop not working). The rationale here was to avoid the pupil 'shutting down' in the first place.
- Talking to the pupil outside the room, possibly to avoid a confrontation happening in front of the pupil's friends (suggested by Dean).

Connor concluded that it would be better to talk to the pupil outside the room, although his reasoning was so that the pupil would not show off in front of his friends. In terms of understanding pupils' behaviour, I had taught the group about Dreikurs' theory of mistaken goals. (See, for example, Dreikurs, Cassell & Ferguson, 2004). You might consider the pupil who 'shut down' to be one whose mistaken goal arises from inadequacy, characterised by giving up. Although Dean and Connor introduced ideas about avoiding confrontation or avoiding the pupil showing off, they did not appear to be guided by the course material.

4.3.2 Reflectivity

Malthouse and Roffey-Barentsen (2016) suggested that science PSTs may not be very reflective, and hence one of the aims of the intervention was to support its development. In this section, I give examples from the data of some first impressions about reflectivity, which are explored further in subsequent chapters.

Reflective journals

The first opportunity for participants to be reflective was completion of reflective journals in the autumn term, and six of the eight participants submitted a journal at that stage. However, this dropped to two participants in the January-February period, which informal conversations with participants suggested was due to their increasing

workload. There was wide variation in the quantity and quality of the written material.

At either end of the spectrum in terms of quantity were Connor and CM. Connor wrote relatively little, in the form of a list of 21 items which presented as rules he had learned about what he needed to do in his teaching (Appendix U). Because these were framed as positive actions to take, rather than as difficulties that had occurred, I had to infer Connor's teaching issues. In categorising them, about 14 of these items are encompassed by the theme of CBM. Of these, Connor's most frequently expressed ideas were to do with keeping the pupils busy (n=5), or applying sanctions (n=5). The issues I categorised as to do with keeping pupils busy were:

- have some questions or an activity on the board to give them something to do as the kids walk in
- don't wait for kids to catch up, just move on
- don't give them time to get off task, keep them busy
- have them do something over teacher talk or Q and A [question and answer]
- even when doing a fun activity, everyone has to be doing something

Those about applying sanctions were:

- Be more harsh with punishment and follow up on threats faster
- Confiscate phones when they are out in class and shouldn't be
- Give detentions to get work done if they don't do any in class
- Give detentions for not doing homework
- Give them a rant if they keep talking, they need to show respect

CM, on the other hand, wrote a lot – giving a blow-by-blow account of 14 lessons, each of which included his plan for improvement. In contrast with Connor, who listed only action points, CM identified a plethora of teaching issues. For example, in the first lesson alone:

- Not enough time spent planning the lesson
- 'Failed' to ensure Blu tack was available
- Found himself engaging more with more vocal (male) students than quieter (female) students
- His board writing was 'scruffy, and the board became cluttered'
- Textbooks were 'futile as they weren't looked at'
- 'There was general low-level disruption'
- 'Calling out was rife'
- He 'was perhaps overambitious to try and cover everything [he] wanted to convey'

In terms of quality, some of the reflective journals (like Connor's) were factual and descriptive, however others revealed something about participants' feelings. When categorising participants' issues from the reflective journals, I used a category that I called 'Teacher feelings' to note what they had to say about how they felt. For me, CM appeared to be rather negative in his use of language, with terms such as failed, futile and rife. Kathryn and Rachael were perhaps more explicit in writing about how they were feeling. In one of her reflective journal entries in November, Kathryn wrote:

> I had a good cry. I don't know why. The class teacher told me I had a wobble in the middle of the lesson. He was right. But all I can focus on is that even if you have a great lesson you still get lots of negative comments. I need a thicker skin. Teacher X said it wasn't the worst lesson he had seen but not the best. He did ask why I was crying. I replied I didn't know. He said he knows how much it means to me and I shouldn't want to be perfect. It's hard. I want to be a great teacher. Anyway, once I started crying I couldn't stop. It was really embarrassing.

Of the issues Rachael raised in her reflective journal, her feelings about learning to teach were mentioned most frequently (n=8). She described herself as feeling inadequate, tired, frustrated, overwhelmed (with work), embarrassed, and out of control.

Critical incident analysis

Another feature of the intervention designed to support reflectivity was critical incident analysis, in which I suggested that PSTs could use Tripp's (1993) Thinking Strategies (Appendix D). Four participants appeared to do so.

Emily applied the strategy of reversal (December critical incident analysis). At that time she was concerned about her lack of experience in dealing with pupils' behaviour, owing to the fact that her first placement was in a girls' independent school, where she observed/experienced very few CBM issues.

> I will try to think of this the reverse way round, rather than waiting for the behaviour to occur – 'in the event of' approach. Rather I need to plan a 'what if' approach so I have responses in mind in line with school B's policy. A bank of responses to challenging behaviour.

Rachael also used reversal. She described a lesson in which some girls were doing some work, but were then doing one another's hair. Here, Rachael was conscious that the pupils were 'engaged in the lesson and learning but don't want to be there.'

Rachael wanted the pupils to enjoy science but she felt 'they don't feel [they] need science in life'. She attempted to see the situation from another point of view, which was that perhaps she was 'not giving enough work, need extension task'.

Also in December, Dean attempted to apply Socratic questioning. He wrote 'Socratic questions why' on his paper, and then:

> Certain members of the class are disruptive. They actively disrupt the class. The others can be [illegible]. Disrupt my talking by asking for pens, etc. Lost their respect for me. I didn't start the right way. Due to the teacher having such good control.

In January, Connor wrote about an issue with a pupil whose mobile phone was visible during class, which was against the school rules. The pupil had been reluctant to give Connor their phone. However, when faced with the possibility of being excluded from class, they had complied. Connor wrote the annotations 'positive, negative, alternative, other views, attitudes, reversal, dilemmas, Why?' down the margin, and attempted to address each point in his writing. Hence, this was a more reflective account than his journal in December had been.

Critical incident analyses were typically rather short, and were not always reflective. Kathryn's analysis (December) was the most succinct. She wrote only:

> LLD [low-level disruption]
> - No boundaries
> - No school policy

4.3.3 Science subject-specific issues

The main difficulties arising which I considered to be science subject-specific issues were the management of practical work; deficits in subject content knowledge; and finding some topics difficult to teach.

Practical work

Perhaps the most concerning example of difficulty in managing practical work came in Dean's December AL set:

> I was doing a practical on the halogens. I didn't give a good enough example, demonstration and safety briefing at the beginning… But I had a student that had taken a whiff of some chlorine, or bromine, I can't remember which. So he was coughing and he needed to go outside. I sent him outside, carried on looking round the class, realizing that at this point everything was going slightly wrong. So during that, I went to go to the door to see if the student

> was okay, because I sent him outside just to get some fresh air, and I'd opened some of the windows to get some of the chlorine and bromine smell out of the room, kind of open ventilation, which is what you're supposed to do in that situation. While I was doing that, I turned around and the teacher that's in the lesson is pretty much dragging another student over to the sink to wash off their arm. During this case, basically, a student had got some bromine water up in a pipette, stuck it to a student's arm, pretended like an injection, and squeezed it against this student's arm. So I didn't see this because I was dealing with another student.

Dean felt that he had not been strict enough at the beginning, and found himself not following through with the school's behaviour policy with this class. I note that Maskan (2007:338) suggests that:

> [Science PSTs] face extra difficulties because they spend most of their time in labs managing practical works and tending to the distribution and collection of the related equipment and making students obey the safety regulations.

Another example came in Rachael's critical incident analysis in January. Her teaching issue was about managing a practical investigation (measuring speed of toy cars). She was concerned that some pupils had 'played with the cars rather than gathering results'. Rachael also felt she should have checked the cars beforehand to make sure they went in a straight line. In her reflective writing, Rachael planned to ask pupils what they were going to do (to check that they had understood instructions); and also to consider the time of lesson (since this one had been on a Friday just before lunch).

Rachael developed this issue further in the January AL set. She added that she found practical work time-consuming and difficult to fit into the lesson. Suggestions from other participants included:

- The PST choosing pupils' working groups (CM)
- Limiting practical work to a very short amount of time (CM)
- Doing a demonstration rather than whole-class practical (Dean)

During questioning, Rachael suggested that the activity may have been too open-ended, and that perhaps some pupils would have benefited from being given step-by-step instructions on the board. She also considered that she could ask for more help from technicians and class teachers 'and remember that I am a trainee and not a full-time teacher as I would like to be'.

Subject content knowledge

Emily expressed some concerns about her subject content knowledge in her reflective journal (October-December). She referred to being asked to teach more physics and chemistry than her subject specialism (biology). She noted:

- Don't have A Level chemistry
- Struggled in Yr 9 lesson on fractional distillation [chemistry]
- Did not have opportunity to practice demo beforehand, and hence did not feel confident
- Concerned about ability to ask/answer questions

Another example of finding it difficult to teach outside their subject specialism came in Kathryn's February AL set. Someone had suggested that it would be a good idea to teach some GCSE Physics in her second placement. This was the science subject that she felt least confident about. She had taught some KS3 topics but she said that she was a bit scared of teaching GCSE. She thought it likely that she would have to teach it in the future because there is a shortage of physics teachers. She was concerned that she would stumble on the maths. She said that she liked maths but she thought she might get caught out, and she didn't want to appear to be 'a bumbling fool'. Kathryn said that she wouldn't want to admit to the science department in placement B 'how rubbish at physics [she is]' until she got to know them. She said she would like to find some crossover with chemistry. At this time, she felt like 'physics is a bit of an alien thing'. However, she said that she was a person who picks things up quite quickly, so felt that she should be able to learn it. Kathryn planned to observe physics lessons, to buy books and revision guides, and to use BBC Bitesize (an online revision site for children). She said that she had some friends and colleagues who could help her.

In her April AL set, Rachael was concerned about developing her questioning. She was asked whether she was able to improvise in making up questions during the lesson. She said:

> I can [improvise] if I've thought it through ahead enough with the material I'm teaching. It has been challenging because I've been doing lessons I've never taught before and doing lots of biology and I'm not feeling comfortable all the time with the material I'm teaching. So I think it comes down to preparation. And I think it's just having enough preparation and confidence and going out there and doing it more.

One of the difficulties, then, was teaching outside of her specialism (physics).

Topics that participants found difficult to teach

In the January AL set, CM's teaching issue was about teaching a challenging Year 9 class. One difficulty he mentioned was:

> The other things about it was there was no practical, unfortunately, cos some of the subject matter I was given was very lecture-based. You could throw questions out 'Why do you think an atom does this?', but you couldn't really do too much to atomic structure – it's a bit of a dry subject without any practical.

In the same AL set, Dean pointed to the difficult of teaching topics which may not be intrinsically interesting to pupils, saying:

> I started with bonding – allotropes, covalent, ionic, metallic. Which, in all honesty, makes me want to shoot myself anyway. I like chemistry and I do like bonding – it's absolutely fascinating when it's in a bit more of a context. But when teaching ionic bonding to them for the first time, I'd rather take a shotgun to my face… It's just fucking boring.

In the December AL set, Kathryn mentioned an incident when teaching her Year 10s electron configuration in atoms. Part of the problem was that the pupils protested that they had already learned the material in the previous two years. Kathryn's view was that it was clear that they could not remember the details, so they needed to do it again.

4.3.4 Participants' progression

Whilst participants' overwhelming focus was on development of CBM, their accounts suggested that they may be moving on to consider the effectiveness of their teaching as the course progressed.

Interestingly, Emily, who was placed in a school where CBM was not an issue, wrote about managing an internet research task, and about learning from science practical work in her January reflective journal. In the second reflection, Emily wrote that in terms of areas for development, 'I need to always link the 'point' of the practical back to the wider scheme of things'. She gave an example that suggested to me that she meant relating the practical back to the ideas about science that were being taught:

> With Year 8, an experiment into the influence of temperature on the rise of dough was carried out – but I needed to place more conscious emphasis on WHY we did this… relating back to conditions microbes need to grow.

It is possible that Emily was showing awareness of course material about practical work, where I had taught Abrahams and Millar's (2008) model for judging the effectiveness of practical work.

In January, Dean raised the issue of a class where none of the pupils were willing to answer oral questions. In his written critical incident analysis, he wrote 'This has killed the pace of my lessons.' He took this issue to the AL set. The open questioning revealed that Dean had already tried a few strategies:

- Waiting for a response, although Dean reported that 'it stops my lesson dead. I feel like it's not really working'.
- A Kahoot! (online) quiz using iPads, about which Dean said:

> So I let them get into groups and then we get some banter going like they're having fun and going through these questions, and they get upset about some of the answers if they're not quite right, and they actually are engaged in that lesson. I get a little bit more communication out of them, I can see where they are struggling with it. And that's fantastic and then when I come to ask them questions about the lesson it just dies.

This comment revealed that the purpose of his oral questioning was to get feedback from pupils as to whether they understood what he was teaching, i.e. that his real interest was assessment (rather than 'pace' *per se*).

In April, only Rachael, Paul, CM and Zoe took part in the AL set. Both Rachael and Zoe were now interested in assessment. Rachael's teaching issue was about questioning:

> I've got a couple of issues but I think they're linked. One of them is about questioning. I was picked up on this that my use of questioning in the lesson wasn't very good, I wasn't asking enough open questions. And that I wasn't using it to gather enough assessment for learning. That I wasn't getting enough feedback from the pupils.

Rachael would have liked to use the mini whiteboards to involve more pupils in giving feedback. The main difficulty seemed to be one of lack of equipment, as it had been hard to ensure that every pupil had a pen and a rubber. It is also possible that this was a classroom management issue as Rachael said that giving out the

equipment had been rather chaotic. She planned to put them out on the desks in advance in the future. She had also used true/false cards to get feedback previously.

Rachael referred to planning her questions using Bloom's taxonomy, which we had taught in the university-based part of the programme (Appendix V), but she sometimes forgot to look at them during the lesson. This point was of interest because it was the only direct reference by a participant to theory that had been taught on the programme.

Zoe wished to increase levels of assessment in the classroom and find a way to make that information useful to guide next lessons:

> I don't feel like they're transferring any skills that we've talked about to their new topic. We've just done metals and now we're doing plant reproduction and I'm struggling to find anything that I can assess in metals that we can build upon and make productive use of in their new topic. It feels like clean slate, move on, 'We're doing biology now kids'.

It became clear from the discussion that, in addition to making formative use of end-of-topic tests, Zoe was using 'no hands up' questioning in class. In another participant's AL set she had been reminded that she could make more use of mini whiteboards, and she also offered 'true/false cards or red/amber/green [traffic lights], to actually get that whole-class feedback'.

In response to being asked if she was taking the data too seriously she said:

> I feel like because we have this much data and we spend so much time doing tests, and marking tests, and doing our RADS, which is re-write a section – and all of that… I feel like we should be doing something with it, because it's a lot of time invested in something to not use.

It is possible, here, that Zoe had internalised course teaching about AfL, although she did not make explicit reference to it.

In the April AL set, it was apparent that CM continued to have similar difficulties with CBM in placement B. He recognised that he was having many of the issues identified by other PSTs at that stage:

> My original task was, incident was, talking about trying to engage the students, and punishment, and when you send somebody out of the class you just lost that motivation, which was kind of what we talked about last time [January]. And I've heard so many things today that I thought 'Oh, yeah, that was an issue for me'. The variety of the lessons was an issue. Trying to keep

> them all on task. It's all so familiar. I'd like to say I've been here to give advice. And now to try to get the same advice back from you guys because I've had the same issues. We've all had the same issues as each other.

CM revealed that he had decided to leave the course. Overall he wished he had started to train to be a teacher 10 years earlier, commenting 'You can't teach an old dog new tricks'. He did not regret his decision to start the course in the first place because he felt that he had got a lot out of it, and he wasn't left wondering 'what if…' His reasoning for leaving included his concern that his pupils were not making enough progress.

4.4 Summary of, and reflection on, themes

In this section, I summarise, and reflect on, the themes emerging from the data, which will be explored further in Chapters 5 to 7.

Most striking was participants' overwhelming focus on CBM. This theme emerged from the data, rather than being something I anticipated from the initial literature review. I was aware, as a course tutor, that developing their CBM practice was important and challenging. However, I was surprised about the extent to which this was their main concern throughout their first school placement. It was a more serious problem than I thought.

It was also striking that, although aspects of CBM were taught in university-based sessions (Appendix K), participants did not refer to what they had learned. Indeed, there was very little reference to theory, overall. The only direct reference was to Bloom's taxonomy in the context of developing assessment (questioning), within Rachael's April AL set.

It appeared to me that there was a progression in some participants' concerns as the year went on. There may be some evidence that they shifted from focusing on CBM to considering pupils' learning. Dean had moved on to thinking about obtaining feedback from his pupils in January, and Rachael and Zoe discussed assessment issues in the April AL set.

Motivating pupils came up for several participants – with Dean's December AL set being an example of discussion of perceived limitations of rewards. Since TS7

(2011:12) includes reference to 'praise, sanctions and rewards' and to teachers needing to 'involve and motivate' pupils (Appendix A), I assume rewarding and motivating pupils to be part of PSTs' CBM practice when discussing it in Chapter 6.

In common with other studies adopting some of the approaches of grounded theory, I continued to read throughout the project. I was interested to find that Furlong and Maynard (1995) had developed a model of stages of PSTs' development, and it seemed to me that there were some similarities between the trajectory they described and my own participants' progression. In Chapter 6, I use these stages as a lens through which to analyse participants' development during the study, and in particular the development of their CBM.

The teaching intervention included strategies that were supposed to develop PSTs' reflective practice. Malthouse and Roffey-Barentsen (2014) suggested that science PSTs are immune to reflective practice. Having carried out initial content analysis of the data, I was interested in why some participants had been more successful than others. It would have been tempting to assume that a participant's success or failure on the programme was linked to their reflectivity. I explore this theme further in Chapter 5.

Being conscious that I am undertaking a professional doctorate, I draw upon a colleague's work to analyse the extent to which participants were reflective. I was keen for the PGCE course on which I worked to be informed by the research of that institution (as well as that from elsewhere, where needed). I believe this to be part of developing a strong research and teaching culture. Hence I have used Zwozdiak-Myers' (2012) model of nine dimensions of reflective practice to analyse participants' reflectivity. Since *Dimension 3* is *Linking Theory with Practice* this analysis encompasses discussion of participants' lack of reference to theories taught in the university-based programme.

The science subject-specific difficulties introduced in this chapter are discussed in two of the chapters that follow. Broadly, I consider difficulties in managing practical work to be classroom management issues, and hence are encompassed by material in Chapter 6. Difficulties with subject knowledge and pedagogy were identified as potential issues in the literature review (2.3.1), which suggested, for example, that

science PSTs are wed to transmission modes of teaching (Loughran, 2007). These are discussed in the context of participants' reflectivity in Chapter 5, since aspects of them may be seen to be related to *Dimensions 6 Try out new strategies and ideas*, *7 Maximise the learning potential of all your pupils* and *8 Enhance the quality of your own teaching*.

In the beginning, I was keen to make a recommendation as to whether the teaching intervention, and particularly AL, should be retained in the PGCE course. Hence, in Chapter 7, I carry out an evaluative analysis of the processes involved. Aubusson *et al*. (2009) suggested that there were four processes of learning that take place in AL, which were *reflection*, *community*, *action* and *feedback*, where reflection enables participants to question their assumptions. This section will pick up on another theme that emerged from the data, which was that the PSTs appeared to have a number of potentially unhelpful assumptions about their pupils, which unfortunately went unchallenged.

Chapter 5. Participants' reflective practice

5.1 Introduction

In this chapter I present the data analysis about participants' reflectivity. Malthouse and Roffey-Barentsen (2014) suggest that science teachers are not very reflective. I hypothesised that a lack of reflectivity might be a barrier to science PSTs learning to teach on a programme that adopted a reflective practitioner model. The teaching intervention included two strategies intended to support development of reflectivity – the DTC (Tripp, 1993); and AL (Bayley, 2015).

I carry out an analysis of participants' reflectivity using Zwozdiak-Myers' (2011; 2012) nine dimensions of reflective practice (Tab.2, p.48). In the literature review (2.3.1) it was suggested that science teachers tend to teach in the way they were themselves taught, relying on transmission modes of teaching. (See, for example, Loughran, 2007). As I explain, modes of teaching can be described by aspects of the nine dimensions. One reason for using the DTC in the teaching intervention was because Tripp (1993) suggested it as a means of overcoming the theory-practice divide. Hence *Dimension 3 Linking theory with practice* is of particular interest.

The RQ and SQs addressed in this chapter are:

- To what extent are participants reflective?
    - To what extent are participants wed to transmission modes of teaching?
    - To what extent are participants linking theory with their practice?
    - To what extent is participants' reflectivity related to their success in learning to teach?

I begin by re-visiting the nine dimensions, describing how levels of reflection were assigned for each of them. The outcome of this analysis is then represented in a heatmap, which tells us something about the extent to which each dimension was observed. I then discuss further the data relevant to the RQ and SQs listed above.

5.2 Assigning levels of reflection

The nine dimensions of reflective practice (Zwozdiak-Myers, 2012) are described more fully in the literature review (2.5.1, Tab.2). I have omitted *Dimension 9*

because it concerns teachers' ongoing professional development, beyond the ITE year. The study was not longitudinal, following the PSTs into their NQT year and beyond. In this section, I describe how qualitative data were analysed to assign levels of reflectivity to the other dimensions.

Dimension 1: Study their own teaching for personal improvement
As described more fully in the literature review (2.5.1) I interpret this dimension taking into account two factors:

- Amount of participation in the DTC (Tripp, 1993)
- An emotional dimension (Zwozdiak-Myers, 2012)

In evaluating participation in the DTC, I omitted data related to writing critical incidents, since Kathryn and Emily did not have opportunity to complete this task in February, being in a different teaching group. Hence I enumerated the action plans, including oral and written reviews of earlier action plans in the later sessions. (Appendix L summarises data collected.) One might argue about whether or not this is a fair representation of this dimension, given that it may depend to an extent on the degree to which participants were organised in completing and handing in written material. That aside, it certainly reflects the number of occasions on which there was evidence of participation in studying their teaching. Contributions were weighted, with a greater weighting given to longer and more detailed ones, such as reflective journals. Appendix W shows a spectrum of participants' participation in studying their own teaching.

Sutton and Wheatley (2003:337) state that 'researchers do not agree on definitions of emotions, mood, and affect'. Indeed, both Zwozdiak-Myers (2012) and Korthagen and Vasalos (2005), whom she cites, use the terms emotions and feelings interchangeably. Additionally, neuroscientists now tend to view feelings as 'the mental representation of the physiological changes that characterize emotions' (Damasio, 2001). Hence for the emotional dimension, I coded transcripts of the AL sets looking for evidence of addressing the following questions, which were suggested by Korthagen and Vasalos:

- How did I feel? (Teacher Feelings – TF)
- How did pupils feel? (Pupil Feelings – PF)

The reason for using AL set data only was that this material existed for all 8 research participants, so was more likely to yield a fair comparison than if I had included material from reflective journals. A summary of the emotional dimension data is shown in Appendix X.

With teacher feelings, for example, in the January AL set, reviewing her progress from December, Kathryn described herself as feeling 'more relaxed' now that she had gained greater classroom control. However, when looking ahead to teaching KS4 physics she said that it was 'a little bit scary'. [RELAXED, SCARED]

An example showing awareness of pupils' feelings was in Connor's AL set in January. He introduced his teaching problem, saying 'there is a big drama between Year 9 – we don't know what – and now they hate each other and won't work together'. [HATE]

Scores for participation and the emotional dimension were aggregated together onto a three-point scale for the purposes of producing a heat map of reflectivity (5.3). Each colour corresponds to a synthesis of two elements:

- Red – non-participation and no emotional dimension
- Amber – moderate level of participation, with little in the emotional dimension
- Green – high level of participation, or a moderate level of participation accompanied by a high score for the emotional dimension.

No participants scored highly in both participation and the emotional dimension.

Dimension 2 Systematically evaluate their own teaching through classroom research procedures

I planned for participants to collect data in school to provide evidence of making progress in overcoming their teaching issues. I provided material for obtaining consent from headteachers, pupils and parents (Appendix N); and I suggested to participants the types of evidence they might collect (Appendix S).

However, none of the participants collected evidence formally. CM obtained consent from the headteacher of his placement school to collect data, which I included as

evidence of being a little more active than the other participants on *Dimension 2*. Hence CM appears as amber on the heatmap, with other participants red.

Clearly, the lack of material is a weakness of my dataset, and I reflect on this in Chapter 7 *Evaluative analysis of the teaching intervention*.

Dimension 3: Linking theory with practice

As noted previously, upon analysing the data it became apparent that participants made little reference to formal educational theory (4.4). However, I also looked for evidence of participants developing personal theories of practice, or 'theories-in-use' (Argyris and Schön, 1974:6). I coded these in terms of Korthagen and Lagerwerf's model of three levels of teachers' professional learning (Korthagen and Lagerwerf, 2001):

- Level 1 (Red) - *Gestalt*
- Level 2 (Amber) – *Schematicization*
- Level 3 (Green) - *Theory*.

These terms have been defined previously (2.5.1). I give examples from the data in the section looking at linking theory with practice in greater detail (5.5).

Dimension 4: Question your personal theories and beliefs

In Zwozdiak-Myers' study, PE PSTs were engaged in action research, and *Dimension 4* was evaluated in terms of the proportion of PSTs who said they were testing a personal theory or belief in their project (Zwozdiak-Myers, 2009). This method of analysis was not open to me in this study. Instead, I looked at *Dimension 4* at four levels:

- Personal beliefs are made explicit;
- There is evidence of questioning one's beliefs;
- Personal beliefs appear to change as a result of group discussion (AL set);
- Personal beliefs appear to change as a result of individual reflection (written critical incident).

I considered questioning one's beliefs individually in writing to be more challenging than doing so in the group discussion, and this is reflected in the traffic lighting (red, amber, green colour coding) of *Dimension 4* in the heat map (5.3).

Several participants articulated beliefs without evidence of questioning them. Two examples of beliefs arose in Connor's written critical incident analysis in January, in the context of confiscating a pupil's mobile phone:

- 'ultimatums are good'
- 'hopefully the punishment teaches them not to do this again in the future'.

In Connor's case, he did at least attempt to apply Tripp's strategies - writing 'positive, negative, reversal, attitudes, dilemmas, Why?' down the margin, and attempting to address each point. This fact accounts for me assigning 'amber' to Connor for *Dimension 4*. There were no examples of participants appearing to change their beliefs as a result of completing the written critical incident analysis alone.

There were few examples of questioning in the AL set appearing to enable personal beliefs to change. A potential example was in Zoe's AL set in January, where Year 8 pupils were wandering around the room. The discussion revealed that Zoe had been more assertive with Year 9 because they had been more challenging. It appeared to enable her to realise that there was middle ground between 'going in all guns blazing' and laissez-faire – she just needed to make her expectations clear to Year 8, and to give regular reminders.

Dimension 5: Consider alternative perspectives and possibilities

I carried out coding for *Dimension 5* in a similar way to *Dimension 4*, i.e. in terms of whether questioning in the AL set led to consideration of other possibilities, or whether these came about as a result of independently writing critical incident analyses.

The December AL set exemplifies why Kathryn's data was categorised as 'red' on *Dimension 5*. Her teaching issue involved a challenging Year 10 group, but unfortunately she would no longer be teaching them in January. Whilst she would continue to teach her Year 7 class, she intended to 'carry on with current strategies', which suggested she was not considering other possibilities.

Where participants' data was colour coded 'green', there was more evidence of considering alternatives, both within critical incident analyses and AL sets.

Rachael's teaching issue in January involved managing practical work. Her critical incident analysis demonstrated thinking about what she could do differently:

- 'I could have tried placing pupils in groups'
- 'I should have 'played' with the cars before the lesson to check they were appropriate for the activity'
- 'I need to get pupils to tell me what they need to do'
- 'I need to consider the time of day/week when lesson planning. This lesson was on Friday just before lunch.'

The AL set enabled Rachael to consider additional possibilities, such as giving clearer instructions, providing less time to complete the practical, or doing a demonstration.

Dimension 6: Try out new strategies and ideas

Zwozdiak-Myers (2012) emphasises PSTs developing a wider repertoire of teaching approaches (2.5.1). In coding for this dimension, I looked for examples of participants recounting the use of different approaches in their teaching. These included those which could be considered to actively engage the pupils – demonstrating to pupils, strategies for obtaining feedback, deploying science practical work, and generic uses of ICT (such as research and presentation). I give examples in the section that considers whether science PSTs rely on transmission modes of teaching (5.4).

Dimension 7: Maximise the learning of all your pupils

In coding for *Dimension 7*, I considered two strands:

- Evidence of personalising learning, taking into account individual pupils' needs
- Evidence of developing AfL practices, in order to make teaching responsive to pupils' learning

In the PGCE programme, science PSTs were taught material about AfL broadly based on Black *et al.* (2004):

- Developing questioning
- Giving feedback
- Using peer- and self-assessment
- Formative use of summative tests

Zwozdiak-Myers (2012) considered questioning to sit within *Dimension 6* as an approach for actively engaging pupils. However, I decided to include it within *Dimension 7* since it had been taught to PSTs as part of their AfL practice.

I categorised examples within participants' accounts in terms of expressing interest in pupils' needs/learning; demonstrating awareness of relevant teaching strategies; showing evidence of implementing strategies; claiming that pupils had made better progress as a result. A potential weakness here is that feedback was largely based on participants' oral feedback or written reviews of their action plans, so evidence of pupil progress was limited. Participants who wrote reflective journals provided more data overall, so this meant that they were more likely to mention material relevant to *Dimension 7* than those who did not.

Dean's data did not contain much evidence for this dimension. In the January AL set, we saw that he was interested in his pupils' progress. His concern about a class where pupils were reluctant to answer questions was that it was hard to gauge what they had learned.

At the other end of the scale, Rachael's concern about students' learning and meeting their needs was evident from the beginning, possibly because she had previously worked as a TA. In her reflective journal from the autumn term, some of her early observations were:

- A Year 11 class where a young teacher was struggling, leading to her teaching 'those who wanted to listen'. Rachael asked herself 'Is this okay? Should teachers help those who want to learn… and leave the others to waste the lesson?'
- On a science lesson with a student with EAL she observed 'inclusion is so important but is not easy to achieve'.
- In a Year 7 lesson which had several pupils with SEN, she wondered 'How much are the pupils learning?' because she felt the teacher was perhaps going too quickly.
- In an early lesson with Year 7 she was 'embarrassed that [she] didn't give [the TA] more guidance', leading to 'not enough inclusion' of the pupils with SEN.

Dimension 8: Enhance the quality of your own teaching

As stated previously, I emphasise development of subject-specific PCK within *Dimension 8*, rather than generic pedagogies (2.5.4). The traffic lighting in the heat map (5.3) reflects where the participants lay on a continuum between referring only to developing the quality of teaching in a general sense (red) to discussing subject-specific methods of teaching particular topics (green).

At the lower end of this scale we had Zoe and Paul, who mentioned only generic teaching approaches. For example, Paul's concerns about teaching strategies entailed how to deal with pace and timing in the lesson (January critical incident analysis and AL set).

At the intermediate level, a number of participants expressed concern about teaching outside their subject specialism, showing awareness of the need to develop this area of their practice (4.3.3).

Some further examples of *Dimensions 7* and *8* are discussed where relevant to whether participants rely on transmission modes of teaching (5.4).

5.3 Heat map of reflectivity

Having analysed participants' accounts, I produced a heat map (Fig.6) to indicate the degree to which evidence of each dimension features in the data from each participant. I note that this heat map is rather impressionistic, but it does have the potential to indicate something about the degree to which different dimensions were observed.

PARTICIPANT	Dimension 1	Dimension 2	Dimension 3	Dimension 4	Dimension 5	Dimension 6	Dimension 7	Dimension 8
CM								
Connor								
Dean								
Emily								
Kathryn								
Paul								
Rachael								
Zoe								

Figure 6: A heat map of participants' reflectivity

The dimensions which may be relative weaknesses are *Dimensions 2*, *3* and *4*. On *Dimension 2 Systematically evaluate your own teaching through classroom research procedures*, although I had hoped that participants would collect data in school to provide evidence of progress in overcoming their teaching issues, this did not happen. I discuss this limitation further in Chapters 7 and 8. I consider *Dimension 3 Linking theory with practice* later in this chapter (5.5). One of the claims made for AL was that it enables participants to question their assumptions (Aubusson *et al*., 2009). Since I consider this to be similar to *Dimension 4 Question your personal theories and beliefs*, I discuss it further in the evaluation (7.3.1).

One problem with science teaching suggested in the literature (2.3.1) was that science teachers default to teaching by transmission. I explore this idea in the next section, making reference to some of the data for *Dimensions 6 Try out new strategies and ideas*, *7 Maximise the learning potential of all your pupils* and *8 Enhance the quality of your own teaching*. Arguably, the heat map suggests that *Dimension 6*, which included adopting active teaching approaches, was a relative strength.

One reason for my interest in the DTC was the suggestion that it may overcome the theory-practice divide (Tripp, 1993). Once I read all the written material of the study, and listened to audio recordings of the AL sets, it became evident that participants made little reference to formal educational theory. Furthermore, they did not make a great deal of reference to any material that was taught in the university-based part of the programme. In light of the fact that I think there is theory that could inform science PSTs' practice (2.3.1), I discuss *Dimension 3 Linking theory with practice* further (5.5).

It was suggested that science teachers are not very reflective, and I hypothesised that this may account for science PSTs doing less well on teacher preparation courses than their more reflective peers. Data about end of course outcomes were available for some of the participants – Emily, Paul and Zoe – and we also know that CM withdrew from the course (4.3.4). Later in this chapter, I consider the extent to which success on the course is related to evidence of reflection (5.6). The heat map does not suggest an obvious link.

5.4 Do science PSTs teach by transmission?

In this section, I consider the extent to which adopting transmission modes of teaching was a barrier for participants. I refer to evidence for *Dimensions 6*, *7* and *8* because:

- *Dimension 6* concerned developing a range of teaching strategies, which might include strategies to actively engage pupils
- One aspect I included in *Dimension 7* was participants' questioning practices, which could be seen to be part of dialogic teaching practice
- *Dimension 8* included development of PCK, i.e. adopting appropriate strategies for teaching the relevant science topic to children

In the literature review, a range of constructivist teaching approaches were suggested as alternatives to transmission, including eliciting pupils' ideas, dialogic teaching, enquiry, responding to pupils' interests, and fostering high-order thinking (Brooks, 1999).

There was a fair amount of evidence that participants adopted active approaches. Sometimes it was not clear exactly what this entailed, however. For example, Paul's mentor wrote in his end of course report that 'Paul has found different strategies to engage the pupils'. Zoe, too, said that she overcame an issue of pupils being out of their seats by using more active approaches, although she did not specify what they were (April review of January action plan).

Several participants discussed difficulties teaching specific science topics. We have already seen that Dean disliked teaching bonding (4.3.3, January AL set). Dean went on to describe some more active subject-specific teaching approaches, although in this instance it was unclear whether he had put it into practice in his teaching:

> They were doing dot and cross diagrams, so when you start off you can put them onto cupcakes – you can use the little silver, like, sweet ball things that you put on cupcakes. You can make a carbon atom, and oxygen atom and things like that. It's actually kind of fun with all the rings, but when it comes to ionic bonding, covalent bonding, the occasional one you can do is marshmallows-cocktail sticks.

Dean had tried a role-play with pupils representing atoms or ions as part of his approach to teaching bonding, although he did not consider it to have been successful with his class at this stage in the programme.

CM wrote about some active approaches he had used in his autumn term reflective journal:

- Asking pupils to construct a mobile of the atom
- In a maths class, having the pupils out of their seats to complete a group task which involved drawing squares and triangles around the room with string.

There was also evidence that participants had involved pupils in carrying out science practical work. In the case of Zoe and Paul it was not clear what the practical work had been. For example, in the January AL set, Zoe was concerned about pupils wandering about during practical work, and not completing their work. As recounted in section 4.3.3, Dean had a particularly difficult experience with a challenging Year 11 group (Dec AL set), and Rachael had also been unhappy with the way she set up a Year 8 practical investigating speed of toy cars (Jan AL set). However, they all appeared to have overcome their difficulties based on their own feedback or that of their mentors. Connor was concerned about organising practical work in a group where pupils had fallen out with one another, but it was evident that he had allowed another class to do a dissection (Jan AL set). Rachael had also taken pupils out of school to count cars on the road in a lesson about frequency (autumn reflective journal). Kathryn had carried out a circus of experiments with Year 7 (autumn reflective journal), and Emily had done an investigation of the effect of temperature on dough rising with Year 8 (January reflective journal).

Many participants appeared to have used ICT in some generic ways (as opposed to subject-specific). Connor and Emily had carried out internet research projects (Connor – Dec AL set; Emily – January reflective journal). Dean and Rachael had used a software tool, called Kahoot!, to carry out quizzes with their classes (Dean – January AL set; Rachael – April AL set). CM had used another software tool, called Plickers, for a similar purpose (Autumn reflective journal).

There was also a fair amount of evidence that participants had been interested in obtaining feedback from their pupils, although there was not much evidence to suggest that they had used the feedback to inform their teaching by the April AL set. Wishing to obtain feedback formed the basis of Dean's critical incident in January. Some examples of relevant strategies were quizzes using software tools, mentioned

above. However, several participants had used mini whiteboards (Rachael – April AL set; Paul – April AL set, Kathryn – autumn reflective journal; Zoe – April AL set). Dean and CM had used exit tickets (Jan AL set), and Rachael had also used true or false quizzes (April AL set). I think it is positive that the participants were showing interest in obtaining feedback, but there was still room for developing their AfL practices, since Zoe's and Rachael's targets in April had been about using the feedback to plan future teaching. One of Rachael's concerns in April was to develop more open-ended questioning, which would be compatible with teaching for understanding, but which had not yet been achieved.

So, there was a range of evidence that participants adopted active teaching approaches. However, there were some topics which they appeared to find harder to teach than others. This seemed to be the case particularly where practical work was not available, or where the topic did not seem to be intrinsically interesting to pupils (4.3.3). Examples included:

- CM teaching atomic structure (Jan AL set)
- Dean teaching bonding (Jan AL set)
- Kathryn teaching electron configuration in the atom (Dec AL set)

In these circumstances, CM described the topic as being 'lecture-based', which gives the impression that he may have been in transmission mode.

Additionally, I note that just because participants included a range of activities in their lessons, it does not necessarily mean they were teaching for understanding. Within the university-based science curriculum programme in the autumn term (Appendix I), PSTs were taught that children may have alternative conceptions, together with a range of methods by which they might elicit information about children's ideas, such as focused questioning; associated word lists; concept maps; and concept cartoons. Whilst participants had begun to use a range of strategies to obtain feedback by April, there was no evidence that they had used diagnostic approaches prior to teaching a topic.

In fact, one of the masters-level assignments completed during the university-based teaching block in January-February included consideration of how to teach a science topic to overcome alternative conceptions. And the other masters-level assignment

(autumn term) included theories of learning, where PSTs' writing often made reference to social theories of learning, such as Vygotsky (1978). Whilst participants appeared to adopt some approaches (e.g. role-play and modelling) that could have formed the basis of talk and discussion about the ideas of science to be learned, it is not clear from the data how they were used. They may just have been used to inform, which would be a transmissive approach.

Similarly, where there were references to participants using practical work and demonstrations, these could have been used to develop understanding. One such approach would be to provide evidence that contradicts pupils' alternative conceptions, with the aim of producing 'conceptual conflict' (Nussbaum & Novick, 1982:183). However, there was no evidence within the data that practical work or demonstration was used in this way. The specific activities mentioned, such as class organ dissection (Connor, Jan AL set) or counting cars in a lesson about frequency (Rachael, autumn reflective journal) were probably illustrative. Similarly, although Rachael's practical work in the AL set in January was posited as an investigation, and although the pupils had played with the equipment, one of Rachael's action points was to give clear step-by-step instructions, so the intended purpose may not have been open-ended enquiry. Again, PSTs' approaches may have been transmissive.

Overall, the range of teaching strategies recounted by the participants suggests that they were willing to attempt a variety of approaches in their teaching, although this may not necessarily mean that their teaching was not transmissive. There was some evidence that they lacked knowledge of alternative teaching approaches for topics they found difficult to teach, which may have led to lecturing.

5.5 Linking theory with practice

At the outset, I was interested in teaching science PSTs material from the field of science education, which I considered could usefully inform their practice. The extent to which the research participants applied theory will be explored in the first part of this section, with the second part exploring participants' practical theorising.

Korthagen and Lagerwerf (2001) suggest that processes of experiential learning have the potential to help PSTs to develop phronesis (practical wisdom), and that this

might be supported by providing opportunities for reflection. In the teaching intervention, I intended to support this development using the DTC (Tripp, 1993); and AL (Bayley, 2015). In Tripp's model, PSTs are engaged in theorising about their practice, rather than applying theory to practice. Korthagen and Lagerwerf's model of three levels of teachers' professional learning (Korthagen and Lagerwerf, 2001). – *gestalt*, *schematization* and *theory* (2.5.1) – is the framework used to analyse the data.

5.5.1 Applying theory to practice

Of the content taught in the university there was explicit reference to only one named theorist, when using Bloom's taxonomy to plan questions (Rachael, April AL set). In the programme, Bloom's taxonomy was taught in a session about questioning. Rachael's teaching issue was that a tutor's feedback on a lesson they had observed was that her 'questions weren't very good'. She said:

> I'm trying to put more questions into my lesson plans, so I have actually got questions written down. I've found Bloom's taxonomy, sort of, sheets that have prompts to make me think a bit wider.

Paul asked her 'What's the ideal situation you want?'

She replied:

> Ideal situation is that the whole class is engaged. So that the questions are open enough and challenging enough, but also accessible enough by all the pupils initially. Obviously you do want to challenge more, but you also want all the pupils to be able to answer the question. And for them to give me some feedback so I can see if they are understanding, and where we're going.

The notion of having questions of different levels of challenge suggested to me that Rachael was attempting to apply knowledge about Bloom's taxonomy which she may have learned about in the university-based session (Appendix V).

Other course material may have influenced participants' teaching. For example, in one section of her April action plan, Rachael wrote 'AfL is gathered in lessons and used for lesson planning with the class in future'. This suggested that she had understood, and was attempting to apply, one of the principles of AfL that was taught – the idea of responsive teaching. For Dean and Zoe, too, there were examples in which it was implicit that they had understood material about AfL.

- In January, Dean was concerned about obtaining feedback from a quiet class, in order to evaluate the success of his teaching

- In April, Zoe noted that she collected a lot of data about her pupils but was unsure how to make use of that information to guide future lessons

Having suggested that some of the university-based material about AfL appeared to have been understood by participants, it is also possible that it did not influence them. Talking about teaching his quiet class, Dean said:

> I did speak to a few teachers and I did try – and it sort of worked – you pose a question and then you get them to pair, and then you get them to respond (January AL set)

This strategy is one which I modelled frequently when teaching PSTs in the university, but Dean appeared to have learned it only by speaking to teachers in school. Similarly, I had frequently modelled choosing pupils at random to answer questions in my teaching, but Rachael was still using 'hands up' (April AL set).

The only other example I found which may be a reference to taught theory came in Emily's reflective journal in January. As noted previously (4.3.4), it is possible that Emily showed awareness of course material about practical work, by suggesting that she needed to link it back to science ideas. I had taught Abrahams and Millar's model for judging the effectiveness of practical work. Briefly (as summarised in Fig.7 and 8, p.121, Abrahams and Millar, 2008:1947 & 1948), there are two interests for the teacher when carrying out practical work, which are whether:

- Pupils carry it out in the way that was intended, observing what they were supposed to observe.
- Pupils learn what they were intended to learn, i.e. making the connection between what was observed and the science ideas they were meant to be learning.

However, Emily's reference was implicit, rather than explicit, so there is a possibility that I infer too much from the data.

Overall, participants appeared to make little reference to formal educational theory.

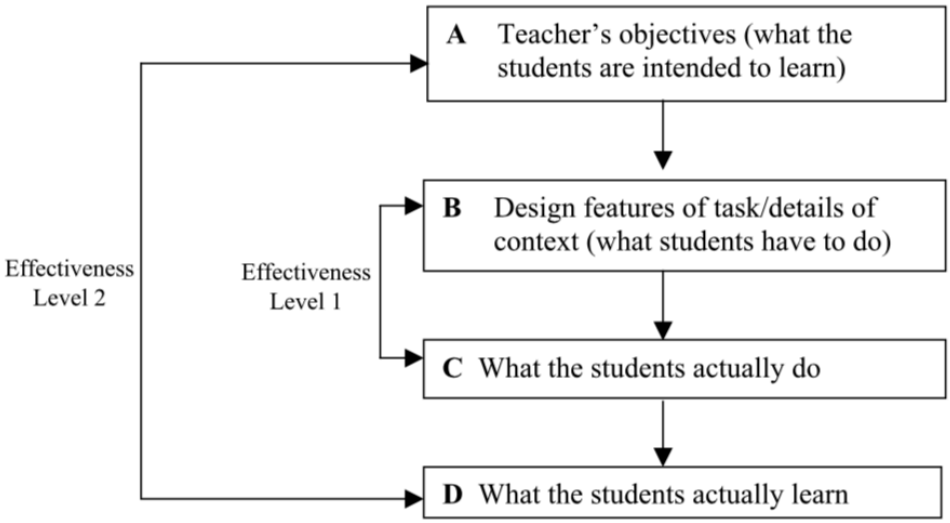

Figure 7: Model of the process of design and evaluation of a practical task

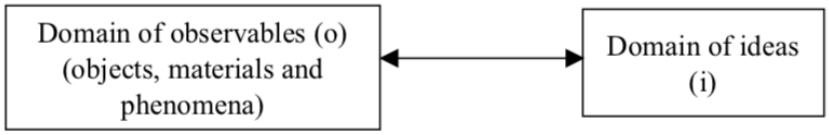

Figure 8: Practical work – Linking two domains

5.5.2 PSTs' practical theorising

In this section, I look at the extent to which participants engaged in practical theorising. Korthagen *et al.* (2001:19) refer to the type of theory discussed in the section above as 'Theory with a capital T', and to theories-in-use as 'theory with a small t'. Having not found a great deal of reference to the former, I decided to look for the latter.

I analysed the data using Korthagen and Lagerwerf's framework of three levels of teachers' professional learning (Korthagen & Lagerwerf, 2001), which are *gestalt*, *schema* and *theory* (2.5.1). In coding for gestalts, I looked for statements from participants which may have revealed their underlying assumptions, and values, which were not accompanied by explanations. I considered that participants had developed schema where they could articulate more coherent ideas about their teaching, i.e. there was some reasoning taking place. They were often able to put their ideas into practice at this level. For theory, I looked for ideas about teaching that could be more widely generalised to different teaching situations, where

statements made by the participants suggested logical connections between concepts, and underpinning explanatory models.

Where participants made a greater proportion of statements that I deemed to be gestalts than schema, they appear as red on the heatmap (5.3). Where the proportions of gestalts and schema were more similar, this is recorded as amber in the heat map. Where there was a higher proportion of schema than gestalts, including where there may be theory, the participants' work is labelled as green on the heatmap.

At the lower level, Kathryn, for example, was a participant for whom there was a relatively high proportion of gestalts. These may have included:

- Wishing to be liked by her Year 10 pupils, or at least not wishing to be seen to be 'a miserable old cow' (December AL set)
- Saying that she was unaware of low-level talk in her classroom, when it may in fact have been that she was choosing to ignore it owing to concern about needing to teach a certain amount of material in the lesson (December AL set)
- Thinking that her Year 10 group should have been better behaved because they were 'top set' (December AL set)
- Being of the view that team teaching would not work because someone needs to be in charge in the room (December AL set)

On this last point, Kathryn said:

> I don't like team teaching anyway because I think there has to be a lead in the room. With team teaching the students don't know who that lead is, they don't know where they stand, they don't know the boundaries.

On the one hand, I agree with Kathryn that at any given time the pupils need to know who is in charge in the classroom. On the other hand, this need not necessarily be confusing when two or more teachers are team teaching. It is a matter for discussion for the teachers before they teach together, and is not insurmountable.

Connor is an example of a participant whose data is coded amber in the heatmap on linking theory with practice. Whilst Connor appeared to reveal some gestalts, he also appeared to make a number of statements that I categorised as schema.

Connor's list from his Autumn reflective journal did not appear to be organised in any particular way (Appendix U). If we were to infer theories about teaching from the most frequent action points, they would be:

- An expression of the everyday idiom 'the devil makes work for idle hands', as a number of points relate to keeping pupils busy so that they are less likely to misbehave.
- That sanctions should be applied for misbehaviour, e.g. confiscation of mobile phones and giving detentions.

Arguably, these are gestalt as I have had to infer an organising framework.

Data from the December AL set exemplify the balance between schema and gestalts. The issue Connor raised was a pupil whom he sent out of the room for passively refusing to work (4.3.1). There is a possibility that this incident brought up a gestalt for Connor, because he said he felt bad about sending the pupil out. The underlying assumption of the group, here, appeared to be that it would be better to keep the pupil in the room, although they did not articulate this idea explicitly, nor explain why that might be important, and hence they are not seen to be working at the level of schema. The discussion revealed that Connor would have felt more comfortable sending the pupil out if he had been aggressive, but he was not.

During this AL set, Dean gave some advice about resolving conflict with a pupil. Connor appeared to draw on Dean's suggestion when he concluded:

> I liked your [Dean's] idea about the kind of taking him outside bit. I think that would be quite helpful because when I've spoken with him, particularly one on one, because he's quite smart and he likes to learn, it's usually gone quite well. But normally when he's like, around other kids, he sort of like wants to show off and you know, show that he's smart.

I may be inferring slightly, but I suggest that Connor was working at the level of schema here. The idea is that you might have greater success talking to a pupil about their behaviour outside the classroom because if you do it in the classroom they might be more inclined to show off in front of their peers.

Similarly, CM gave Connor some advice about having a backup plan:

> Yeah, trying to sorta second guess if the IT is gonna work, so have a backup plan or something, in the event of this… do this and don't wait for instructions…

Connor responded by integrating this idea into his conclusion, making links to what experienced teachers had been saying to him, which I suggest is also evidence of operating at the level of schema:

> And then, um, also saying the additional task thing, the other teachers have told me that it's always important to have extension work ready, so, in case the laptop blows up or whatever, or you don't have your PowerPoint anymore, you need to have something ready just in case, so like, having things set in place for when things may go wrong is also quite a good thing to do.

He further concluded 'I think it comes down to going through the behaviour policy', although he did not articulate his reasoning for this, so I categorised it as gestalt. The underlying gestalt might be 'I need to follow the rules'.

The difference between Dean and Connor on this dimension was that, of all the participants, Dean came closest to articulating a theory. This was observed in his advice to Connor about the pupil who had 'shut down':

> So you give them a chance. So you go 'Right, okay' So you get up to your C2 [second warning]. You give them a chance. You go, right, you then go, and this is where you're taking them out of the room. And then that way they're less likely to get defensive because that way you're not doing it in front of their friends. You've got a little bit of an extra step. By taking them outside you've got rid of that flight or fight moment that they're having with you because you've put them into a situation where you've gone 'You're doing something wrong' and that person's gone 'no I'm not' and then locked themselves down.

I suggest that Dean has at least a schema here about how to approach a situation in which there is a confrontation between teacher and pupil. Perhaps it is moving towards being a theory because he makes a link with the fight-or-flight response, which has a basis in psychology. This idea could reasonably be applied to a range of teaching situations.

Looking at the heatmap (5.3), by this method of analysis, three participants' responses are categorised as 'red' on dimension 3 (CM, Emily and Kathryn), three are categorised as 'amber' (Connor, Paul, Rachael), and two are categorised as 'green' (Dean and Zoe). So, unfortunately, overall, some participants appeared to be engaged in putting theory into practice, or in practical theorising to a rather limited extent. This observation raises a question about what participants were learning about teaching, and how they were learning it.

5.6 Comparison of participants' course outcomes with their reflectivity

In this section, I discuss the extent to which participants' reflectivity was related to their course outcome. In 2016-17, university tutors and school-based mentors commonly assessed PSTs' teaching referring to national guidance (UCET & NASBTT, 2012). Since PGCE courses have external examiners, whose role is to check that standards are similar across institutions, and since Ofsted inspects the accuracy of judgments made by ITE providers, it may be reasonable to assume that participants' grades reflect the strength of their teaching.

Of the eight participants, we know the eventual course outcome, formally, for only four, through their end of course reports:

- Emily and Zoe (both biology specialists) completed the course, and their teaching was graded 'outstanding'
- Paul (a chemistry specialist) completed the course, and his teaching was graded 'good' overall, with three TS graded 'outstanding', which is close to the good/outstanding borderline
- CM (specialising in physics with mathematics) withdrew from the course in April

I think it is reasonable to assume that CM thought that his final grade would be 'inadequate'. If he was on track to pass the course (i.e. 'requiring improvement') there is no reason to withdraw.

Figure 9 shows a modified version of the heat map, in which only the four participants whose final grades are known are represented.

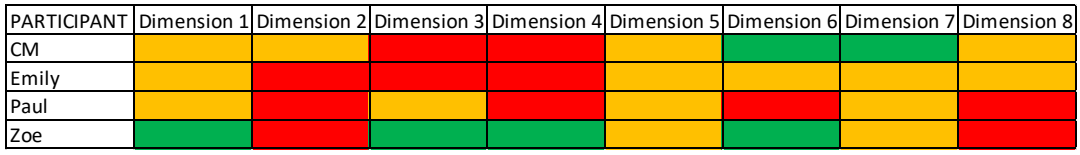

Figure 9: Modified heatmap

There is not a simple correlation between participants' reflectivity and course outcome.

Notably, I considered CM to have provided greater evidence of *Dimension 7 Maximise the learning of all your pupils* than other participants. Several examples of his concern for pupils came in his reflective journal in November.

The first entry was about spending too long on background information about pupils. He noted, however, that this 'prepared me for some events such as a diabetic pupil who suddenly had to leave early with a colleague'. Hence CM is seen to be aware of an individual pupil's needs from the very beginning – although not learning needs in this instance.

CM also expressed some concerns for equity, e.g. 'lots of hands would go up and it was easy to select an equal group of boys and girls'. In an early lesson with a Year 7 class, he was aware that he would need to 'differentiate for the higher achievers' in future.

Later, he wrote about working with a lower-attaining Year 8 group:

> Armed with the knowledge that one of the ASD students was taking a trip on the Santa Special train… I decided to base part of the lesson around finding a route from Town X to the Y Railway to improve the engagement of this particular student who had a difficulty focusing during previous lessons.

Arguably, based on my professional experience, it is unusual at this early stage in the PGCE course to see science PSTs taking steps to adapt their lessons to meet individual pupils' needs in this way.

Alongside Zoe, CM also appeared to present a relatively large amount of data in support of *Dimension 6 Try out new strategies and ideas* (5.4). Where CM may have struggled was in teaching science topics where there was no practical work, referring to teaching atomic theory as 'lecture-based' (4.3.3).

CM's profile appeared weaker on *Dimensions 3 Linking theory with practice* and *4 Question your personal theories and beliefs*, but so did Emily's. I consider *Dimension 4* in a later chapter in the context of evaluating the success of AL in allowing participants to question their assumptions (7.3.1). Perhaps not entirely divorced from my later comments about *Dimension 4*, within *Dimension 3* both participants appeared to reveal a rather high proportion of gestalts, not all of which might be considered helpful.

Emily, for example, expressed some gestalts in the December AL set. She was afraid of going into a second placement in a state school. She anticipated that something

more extreme than low level disruption would occur (a violent outburst), describing the school she was in as having 'no rowdy boys, certain demographic, higher-achieving girls'. Some of these fears might have been reasonable, since they were based on what other PSTs had recounted on social media, with an example being an incident in which a door had been ripped off a doorframe by a pupil. But to some extent these may have been stereotypes, related to attainment level, gender and socio-economic status, that went unchallenged.

CM, too, expressed fears about managing pupils' behaviour, which could be considered to be gestalts. For example, in his December AL set, CM discussed a difficulty in dealing with a pupil (Brian) who was talking back to him, whom I considered to be challenging CM's authority. He recounted:

> Then there's one, even if you get them all quiet, there's always this one boy, there's a little gaggle of girls with him, and they just seem to be constantly talking all the time… And, so you say, 'Brian, thank you' and he'll be quiet, and then he'll start kicking off again, so I just try and give him the look. You know, everybody's quiet, and I stop talking and I just give him the look and he'll turn around and say 'What?' So, he'll sort of look at me, saying:
> 'Well, what have I done wrong?'
> 'You're talking again.'
> 'No, I'm not'
> You can see that he is, you know.
> 'I don't want to hear it'
> And then he comes back… with a smart comment.
> 'You know if you don't want to hear it, then don't listen to it'

The situation appeared to raise a gestalt for CM, which was that he was afraid of what might happen if he challenged Brian:

> That's my fear is that he'll start trying to mix it with me. And I don't want to get into it with him.

He appeared to realise that he needed to use sanctions. However, he said:

> But it's just, having that confidence, I guess just having the balls to say 'Right, this is it, I am your teacher, this is my classroom, get out of my classroom.'

CM appeared fearful about what would happen if he were to assert himself with his more challenging pupils, referring for example to 'having that courage to have that first blood'. In his January AL set, he wondered whether his difficulty started at the beginning of a lesson with both he and the boys 'gunning for a fight'. He also said 'That's my fear is that he'll start trying to mix it with me. And I don't want to have

to get into it with him.' All these expressions evoke an impression that his fear is of physical violence.

CM, too, expressed some views about pupils which could be gestalts, and could be construed as being unhelpful. When discussing Brian, he suggested that the problem might be a 'home-based thing', and there was another instance in which he suggested that Year 9 pupils are more difficult because 'their hormones kick in' (January AL set). Whilst these could be reasonable explanations for some classroom behaviours, I think these may be (respectively) an incorrect assumption, and an over-simplification, which may not help someone to improve their teaching. CM described the more challenging pupils as 'disruptive ones' (January AL set), 'miscreants' and 'troublemakers' (both appearing in both December and January AL sets). Arguably it is more helpful when managing behaviour to try to separate the behaviour from the pupil. I aim to teach PSTs to try to like the pupil and to dislike the behaviour, rather than to label them.

Moving on into the February AL set, Emily was able to describe a vision and rationale (perhaps a schema) of what she wanted to achieve in managing her classroom and how she was going to do it (perhaps supported by Kathryn's questioning):

> I don't want my battle to become me putting out small fires round the room, moving around the room and dealing with them individually. Because it wastes time and that's something that I don't want to have to waste my time doing. You want to be focusing on the bigger picture, the whole class, and actually doing something productive.
> I wouldn't immediately jump in and do a super-fun, super-risky practical with a new class. I'd make sure I set out my expectations with the new class so that they know I expect this level of good behaviour and have the same amount of cooperation with myself as they would have with their own class teacher. So it's all about gaining that trust, the right to be able to do these kind of fun things with the class…
> I will make the obvious effort to go and observe the classes I'm teaching and see how they behave with other teachers, so I can get a feel for how the class is as a whole. If there's any particular issues with any small groups in that class, and then have strategies to tackle those small fires should issues with individuals arise.

Another possible gestalt emerged here. In discussion of her plans for managing behaviour in placement B, she said that she thought that if she gained pupils' trust she would be able to do 'fun things' like practical work. So, it seems to me that in

common with several other participants, Emily wanted her pupils to have fun, but the reason for this was not articulated.

CM too, had some examples that might be considered to show developing a schema. During Connor's AL set in December, CM made a suggestion about giving pupils options:

> Yeah, I think giving them options is something that gives them… it empowers them. They can control the situation then. Cos say if you give them the choice 'Either you can do this now or you can come back at lunchtime, you can do it in lunch break when it's nice and quiet for you.' It gives them that option, but they must do that task.

I suggest that this statement is moving towards a schema for dealing with pupils' behaviour, since it involves overarching ideas of power and control. Since the pupil does not really have a genuine choice in this situation, I introduce the term forced choice. I think it is quite common for teachers to use forced choices. I suggest that this approach assumes the teacher's, or the school's, power over the pupil, without considering the extent to which this is a helpful approach in the socialisation of young people. Hence categorising the forced choice as schema rather than theory.

There were some other areas in which CM appeared to be at least comparable with other participants. On *Dimension 1 Study your own teaching for personal development*, for example, CM had shown greater commitment to the project than Paul by keeping a reflective journal during the autumn term. None of the participants collected data in school as evidence of overcoming their teaching issues, which sits within *Dimension 2 Systematically evaluate their own teaching through classroom research procedures*. However, CM did at least obtain permission from the headteacher of his placement school to do so. On *Dimension 5 Consider alternative perspectives and possibilities*, CM also appeared comparable with Paul. For both of them, evidence came from being able to adapt their ideas with the support of others in AL sets, rather than independently within written critical incident analyses.

In the December AL set, Paul said he had too many targets from different teachers, and was concerned that they would think he was not acting on their advice if he did not meet them all. Dean suggested picking one target for each teacher and asking them for feedback on that, a strategy which Paul decided to adopt.

In the January AL set, CM had lost enthusiasm during a lesson when he sent some pupils out of the room. Connor asked him what he could do to brace himself to not let it get him down. In replying, CM expressed concern about the amount of time spent trying to get the class to be quiet, and feeling like he had not taught them anything. Connor then asked whether it was alright to spend time dealing with behaviour. CM acknowledged that perhaps it does not matter – that time might be well spent in a first lesson with a class setting ground rules and getting 'the seating plan the way I want it to be'. Thus we saw his perspective change.

Additionally, within *Dimension 8 Enhance the quality of your own teaching*, CM is 'amber' on the heatmap, whereas Paul and Zoe appear 'red'. This is because I had interpreted *Dimension 8* as to do with developing subject-specific PCK. Paul and Zoe mentioned only generic teaching approaches, whereas CM had mentioned strategies for teaching particular topics.

A further point of note here is the comparison between Zoe and Emily. Both obtained an 'outstanding' grade for their teaching practice but the heatmap suggested that Zoe was much more reflective than Emily. This may suggest that one does not need to be a reflective practitioner in order to succeed on an ITE course in England, although perhaps Emily may have developed greater reflectivity after she ceased to contribute to data collection.

Overall, there was no obvious connection between reflectivity and course outcome for these participants. Unfortunately, CM did not complete the course. However, there were some ways in which he did at least as well as other participants in demonstrating the dimensions of reflective practice. On the one hand, this may mean that this was not a very good method of finding out the extent to which PSTs are reflective. On the other hand, perhaps reflectivity is not the main factor in the development of science PSTs' teaching.

5.7 Summary and bridge to the next chapter

Firstly, science PSTs may not be wed to transmission modes of teaching. There was plenty of evidence of them adopting active strategies. They aimed to develop their questioning to obtain feedback. However, there was no reference to using

questioning diagnostically, or to creating conceptual conflict, which we might have expected to see if participants were aiming to develop pupils' understanding. Whilst participants adopted some active teaching approaches, there were some topics that they found more difficult to teach because they lacked practical work, and these areas were sometimes deemed to be lecture-based. Perhaps participants lacked knowledge of alternative teaching approaches, rather than being wed to transmission.

In terms of linking theory with practice, participants made little reference to formal theories of education. Whilst there was some evidence of development of schemas, participants rarely articulated anything that was coherent enough to be deemed to be a personal theory of practice.

My analysis suggests that there was variation in the reflectivity of the research participants, but this is not necessarily related to the course outcome. CM, who withdrew from the programme, was a case in point, since he appeared to be at least as reflective as others across several dimensions.

Malthouse and Roffey-Barentsen (2014) suggested that science teachers are not very reflective, and I hypothesised that this might be a difficulty on a course that adopts a reflective practitioner approach. Whilst there were some notable weaknesses, such as in *Dimension 3 Linking theory with practice*, overall, participants demonstrated evidence of many of the dimensions of reflective practice. Perhaps Malthouse and Roffey Barentsen go a little too far in suggesting that science teachers are immune to reflective practice.

So, if reflectivity is not necessarily the problem, what is? The predominant concern of participants emerging from the data was CBM. This concern is explored in the following chapter, as part of a broader discussion about participants' development during the programme.

Chapter 6. Barriers to participants' development

6.1 Introduction

In Chapter 5, I suggested that whilst there was variation in the reflectivity of the participants, this did not necessarily explain why some of them made better progress than others. In Chapter 6, therefore, I consider the findings that emerged from the data relating to the *prima facie* RQ:

- What are the barriers that science PSTs face during their PGCE?

I begin this chapter by presenting a summary of my thematic analysis. Participants' predominant concern was CBM. This was not wholly unexpected, based on my professional experience of working with science PSTs, and indeed some literature (2.5.2), but they appeared to focus on CBM for a more prolonged period than I expected. In common with other areas of their practice, they made little reference to theory they were taught in relation to CBM. In some cases, participants seemed to find it particularly difficult to move on in developing their CBM.

In common with other studies which adopt some of the approaches of grounded theory, I continued reading during the project. This led me to compare participants' progress with the stages of development proposed by Furlong and Maynard (1995). They suggest that an important component of developing CBM is fostering appropriate working relationships with pupils. The subsequent parts of this chapter address the following RQ and SQ:

- How does the development of participants' teaching compare with the stages of development of PSTs in the literature?
    - Why might participants have found it difficult to develop CBM?

6.2 Outcomes of the thematic analysis

I begin by summarising teaching issues the participants raised. I present this material chronologically, because one of the matters I discuss subsequently is the sequence of participants' development, referring to Furlong and Maynard's (1995) stage model. Appendix Y describes categories used to code the data, which appear in data tables in the rest of this section.

6.2.1 The autumn term

Reflective journals

Six participants handed in reflective journals written between the introductory session in October, and the December AL set. Participants wrote different amounts in their journals and some wrote many more comments that could be considered teaching issues than others. For example, CM wrote 86 items that I coded as teaching issues, whereas Emily and Zoe each wrote only 13. Thus, when enumerating the relative importance of each type of difficulty, I did not simply count the frequency, but rather calculated a weighted average. Table 4 and Figure 10 (p.134) show the most common categories of teaching issue, but includes only the top five items, which account for just over 70% of all teaching issues recorded. CBM issues accounted for just over 46% of each participant's teaching issues on average.

	Coding category				
Participant	CBM	Time management	PST feelings	Subject content knowledge	Mentoring relationships
CM (n=86)	48	15	0	0	0
CM percentage occurrence	58.1%	17.4%	0.0%	0.0%	0.0%
Connor (n=20)	12	3	0	0	0
Connor percentage occurrence	70.0%	15.0%	0.0%	0.0%	0.0%
Emily (n=13)	4	2	0	4	0
Emily percentage occurrence	30.8%	15.4%	0.0%	30.8%	0.0%
Kathryn (n=34)	3	0	5	0	10
Kathryn percentage occurrence	11.8%	0.0%	14.7%	0.0%	29.4%
Rachael (n=26)	6	1	9	0	0
Rachael percentage occurrence	23.1%	3.8%	34.6%	0.0%	0.0%
Zoe (n=13)	11	0	0	0	0
Zoe percentage occurrence	84.6%	0.0%	0.0%	0.0%	0.0%
Mean percentage occurrence	46.4%	8.6%	8.2%	5.1%	4.9%

Table 4: Most frequent issues identified in reflective journals from Oct-Dec

For four participants (CM, Connor, Emily and Zoe) CBM issues were their most frequently-mentioned concerns (with Emily being equally concerned about her subject content knowledge). Frequent CBM issues included:

- Needing to develop presence, assertiveness and voice projection (CM and Zoe)
- Pupils taking time to be quiet/low-level disruption/low-level talk or giggling (all four)
- Needing to keep pupils busy to prevent off-task behaviour (Connor and CM)

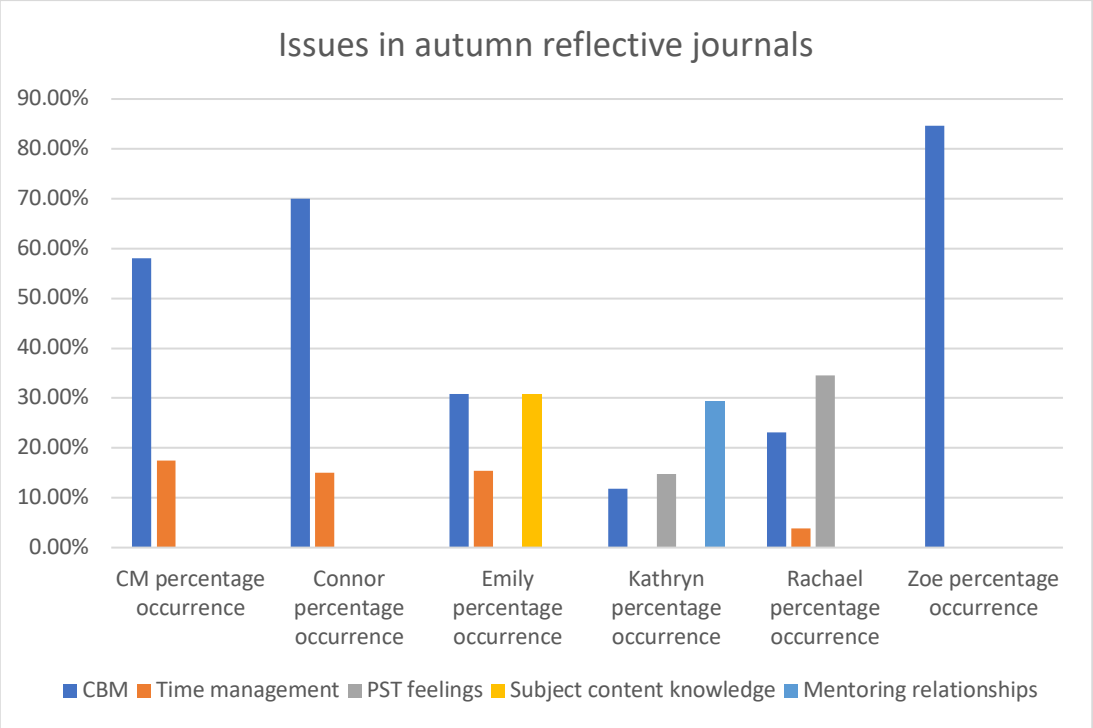

Figure 10: Frequencies of teaching issues in autumn reflective journals

Whilst I had categorised Rachael's most frequently-recorded issue as 'PST feelings', given that Rachael wrote material such as 'the lesson felt chaotic', it is possible that these feelings were brought up by her concerns about her CBM, although she did not explicitly write this. And although Kathryn more often wrote about difficulties to do with relationships with school colleagues/school management, this too may have been related to CBM. For example, one of the reasons why Kathryn had felt undermined in a lesson was because the class teacher had stepped in to tell off 'troublemakers'. Kathryn also recounted dealing with a pupil throwing things across the room, and difficulty managing low-level disruption, amongst her teaching issues.

Perhaps Kathryn's difficulties with CBM explain why the class teacher felt the need to intervene.

Critical incident analysis

Participants then selected issues from their reflective journals (where completed) to consider in their critical incident analysis in December. Their teaching issues are shown in Table 5. Because the critical incident analyses were much shorter than the reflective journals, I have simply given the frequency with which each category of issue occurred.

In the critical incident analyses, four of the eight participants (CM, Dean, Emily and Kathryn) included difficulties exclusively to do with CBM. Of these, the most frequently raised issues were dealing with disruptive pupils, low-level disruption, and getting pupils to be quiet.

	Coding Category					
Participant	CBM	Mentoring relationships	Teacher feelings	Inclusion	Engagement	Time management
CM	2					
Connor						
Dean	4		1			
Emily	1		2			
Kathryn	3					
Paul		3				
Rachael	1			1	1	
Zoe	1			1	1	1
Frequency	12	3	3	2	2	1

Table 5: Summary of issues in December critical incident analyses

AL sets

Teaching issues identified by participants in the December AL set are shown in Table 6 (p.136). I categorised seven of these eight teaching issues as CBM. Of these, the issues raised by CM, Kathryn and Zoe had similarities, since all concerned them wishing the pupils to be silent so that they could speak to the whole class. Emily's experience was somewhat of an outlier – she was concerned about preparation for her second placement, since she was not having to deal with misbehaviour, and was not able to observe other teachers dealing with it either.

Participant	Issue in AL set	Category
CM	Dealing with a pupil's backchat	CBM
Connor	Pupil passively refusing to work	CBM
Dean	Dealing with disruptive pupils, including managing practical work safely	CBM
Emily	Not experiencing any challenging behaviour	CBM
Kathryn	Pupils talking over the teacher	CBM
Paul	Too many targets	Mentoring relationships
Rachael	Pupils off-task (plaiting one another's hair)	CBM
Zoe	Getting the attention of a chatty class	CBM

Table 6: Teaching issues raised in the December AL set

6.2.2 January-February

Reflective journals

Only Kathryn and Emily completed and handed in reflective journals during January-February. Kathryn wrote much more than Emily, and hence raised a greater number of different teaching issues, with Kathryn raising 17 and Emily raising only two. Because there were so few journals, and because of the disparity in the number of teaching issues mentioned, I have not included a table.

For Kathryn, again, the category of difficulty that arose most frequently was CBM (eight of 17). Emily raised different issues in her reflective journal this time. I thought this was interesting because, in the apparent absence of behavioural issues in the girls' independent school in which she was placed, Emily was able to focus on developing other aspects of her teaching.

Critical incident analysis

Five participants (Connor, Dean, Paul, Rachel, Zoe) completed and handed in written critical incident analyses in January. A summary is shown in Table 7.

Again, the issues fell most frequently into the CBM category. The participants raised different CBM issues than one another – there was no obvious pattern. These included dealing with:

- a pupil with their mobile phone out during the lesson (Connor);
- a defiant pupil (Connor)
- pupils being too slow to complete their work (Paul), or off-task (Zoe);
- pupils being too chatty (Zoe);
- pupils playing with equipment during practical work rather than doing it as intended (Rachael).

	Coding category				
Participant	CBM	Pupil feelings	Inclusion	Time management	Engagement
Connor	2	2			
Dean		3		1	
Paul	1		2	2	
Rachael	1		1		
Zoe	2				1
Frequency	6	5	3	3	1

Table 7: Summary of issues in January critical incident analyses

Interestingly, where previously I had a 'teacher feelings' category, I now had a 'pupil feelings' category. Dean and Connor gave consideration to how pupils might feel about the situations they were dealing with. For example, in the incident where he confiscated a pupil's mobile phone, he noted that 'now the pupil feels sad'.

AL sets

Table 8 (p.138) shows teaching issues that participants chose to discuss in the January/February AL set. Again, the majority of participants' issues could be categorised as CBM.

I had originally thought that Dean's issue might be CBM, since pupils were not complying with the teacher's request, or a time management issue. Dean initially introduced the problem as a difficulty that was 'killing the pace' of his lesson.

However, I ultimately considered this a question of developing assessment, rather than a CBM issue, because during the AL set it became evident that Dean was concerned about obtaining feedback from the class (4.3.4).

Participant	Issue in AL set	Category
CM	Difficulty in maintaining enthusiasm after sending out three 'disruptive' pupils	CBM/teacher feelings
Connor	Pupils had fallen out with one another and now refused to work together	CBM
Dean	Quiet class not answering oral questions in class	Assessment
Emily	Not having gained experience of challenging behaviour during placement A	CBM
Kathryn	Developing subject knowledge for teaching physics	Subject content knowledge
Paul	Building a rapport with a challenging class, including an incident in which a pupil had been very rude to the PST	CBM
Rachael	Pupils playing with equipment during practical work rather than carrying out the investigation as intended	CBM
Zoe	Pupils wandering around the classroom	CBM

Table 8: Teaching issues raised in the January AL set

6.2.3 April

No participants submitted reflective journals written in this period; and, because the seminar was carried out as a twilight session, there was insufficient time to complete critical incident analysis. Four of the participants took part in the April AL set. Their teaching issues are summarised in Table 9 (p.139).

CM revealed that he was leaving the programme at this stage. His main stated reason was that pupils were not making enough progress. However, the lack of progress may have been related to CBM, as he said:

> My original task was, incident was, talking about trying to engage the students, and punishment, and when you send somebody out of the class you just lost that motivation, which was kind of what we talked about last time [January].

For me, this suggested that CM still had the same difficulty as in the previous AL set, which was loss of enthusiasm for the lesson when he had sent several pupils out for misbehaving.

Zoe was now concerned about making productive use of assessment data, and Rachael about questioning. I consider questioning to lie in the assessment category because it was taught in the AfL strand of the science curriculum programme (Appendix I).

Participant	Issue in AL set	Category
CM	Trying to maintain discipline in the classroom and to maintain enthusiasm	CBM
Paul	Pupils not completing tasks within the allotted time; pupils talking to one another rather than working	CBM
Rachael	In an observed lesson a tutor had commented that her questioning was not very good	Assessment
Zoe	Increasing levels of assessment; and using assessment information to guide teaching	Assessment

Table 9: Teaching issues raised in the April AL set

Paul had difficulty with a class in which he was concerned that pupils took too long to complete tasks, because they would talk to one another instead. The fact that he felt he had to keep attending to different pupils to keep them on task might imply that there was a considerable amount of off-task behaviour, and he said that they were talking to one another rather than working. Hence I categorised it as CBM. However, Paul was also concerned about the pupils' learning, as later in the AL set

he referred to the problem being that pupils were too slow to meet the learning objectives, and hence that they were not progressing at the rate he felt they needed to be.

It may not be appropriate to generalise from so few participants, but there is a possibility that they were moving on from their main concern being about CBM at this point, with the possible exception of CM.

6.3 Stages of development of participants' teaching

In this section, I compare participants' progress with that described in literature. I carry out this analysis in terms of Furlong and Maynard's stages of PSTs' development (Furlong & Maynard, 1995). As described previously, the authors suggest that there are five stages of development during ITE – *Early Idealism*, *Personal Survival, Dealing with Difficulties, Reaching a Plateau,* and *Moving On* (2.5.2).

In the period in which the research took place (up to April), participants' issues fell within the first three of these categories, and hence I limit myself to introducing the most frequently-observed examples within those. I note that Furlong and Maynard did not suggest a linear progression through stages, and I do not claim a linear progression within my data.

6.3.1 Stage One - Early Idealism

Within the data, there were numerous examples which resonated with Furlong and Maynard's (1995) description of the *Early Idealism* stage. These included participants wanting to have friendly classroom relationships with their pupils, and to have a warm classroom atmosphere.

In his December AL set, for example, CM discussed his difficulty in dealing with a pupil (Brian) who was talking back to him (5.6). In response to other participants' suggestions, he concluded:

> It'll be the first time that I've actually disciplined anybody. I'm seen as this meek, quiet, wants-to-be-liked type of guy. I'm gonna have to be 'no more Mr Nice Guy'.

Whilst other participants were less explicit in seeing themselves as someone who wants to be liked, there were similar occurrences for others as well.

In the January AL set, CM, Dean and Paul were all keen to develop a rapport with their classes. Paul felt that he had developed a good working relationship with younger pupils at this point, particularly mentioning a Year 7 lesson in which he had done a Gandalf impression (4.3.1). Paul was unsure how to develop the same working relationships with his Year 10 class.

Participants were also keen to have a warm classroom atmosphere. For example, in the January AL set, Connor's teaching issue was dealing with some girls who had fallen out with one another and now refused to work together. His preferred outcome was 'everyone is happy'. I see the participants' references to 'fun' as being relevant here, which came up several times. See, for example, Emily's February AL set (5.6).

Additionally, in terms of creating a caring atmosphere, in April, Zoe said that she wanted to be:

> the teacher that knows what you're working on, and what you're good at, and what you need help with. Makes them feel like they're in safe hands – not just someone who's come into their school and is trying to teach them for a bit.

Arguably this was a rather idealistic view, and I wonder to what extent it can be realised in secondary teaching, since science teachers generally see their pupils for only a few hours each week.

Furlong and Maynard (1995) suggest that PSTs need to put their ideals on hold while they focus on survival.

6.3.2 Stage Two – Personal Survival

The data also resonated with Furlong and Maynard's (1995) description of the *Personal Survival* phase in a number of ways. They found it difficult to assert their authority, and to communicate clear expectations. They were tested by their pupils, and experienced strong feelings.

In the first teaching review, Dean's mentor had suggested asserting his authority as an area for development. And at the same point, Zoe's mentor suggested that she

needed to ‘build on her assertiveness’. Lack of assertiveness perhaps came across most strongly for CM. In his December AL set, in discussing how to deal with Brian (5.6), he wished he had the ‘cojones’ to use sanctions. CM wondered why the class teacher had not changed the seating plan, and appeared not to realise that he could have done so himself. Another example came in his January AL set in January, in which he discussed a loss of enthusiasm after he had sent three Year 9 pupils out of the room for causing disruption. By this time, CM was aware that he could have changed the seating plan for this class, but he still had not done so. He thought that separating the pupils might have made a difference. However, he thought it would take ‘guts’ to do this in placement B, and he was concerned about whether pupils would bear a grudge against him if he did so.

Furlong and Maynard (1995) suggest PSTs have difficulty at this stage because they do not know classroom rules and routines, nor how to deal with difficulties. The notion of needing to have clear expectations of pupils’ behaviour came up in the data at numerous points, exemplified by Zoe (4.3.1). However, participants sometimes seemed to know what to do, but were not putting it into practice. Dean, for example, was able to articulate a stepped approach to behaviour management in giving advice to his colleagues in the December AL set (5.4.2), and expressed frustration that he was not acting on his own advice. Several participants appeared reticent about following through with sanctions, exemplified by CM (4.3.1) rather than being unaware of what they needed to do. One of the difficulties may have been the reticence of class teachers to hand over control. This was most strongly exemplified by Kathryn (December reflective journal), who felt undermined by the actions of a class teacher who:

- stepped in to tell off pupils;
- audibly commented to pupils more than once on her running round like a 'blue-assed fly';
- stopped pupils to check they had read instructions, and to tell them off for not reading the instructions.

Another example of being at the *Personal Survival* stage was participants feeling like they were being tested by their pupils. This was something that Dean said in his AL set in December, when he discussed dealing with disruptive pupils. And CM’s descriptions of his interactions with Brian and other pupils tend to suggest that his

pupils were testing him, too. One example came in the December AL set, and was raised by CM as a precursor to talking about his difficulty with Brian:

> I had the issue on Friday afternoon, Year 8, graveyard shift. You give the instructions out to them, and some get on with it, and one's just sitting there chatting with his mate. And you sort of go patrolling round, and you say 'You haven't written anything yet' and it's when they come back with the smart comments – oh, I can't write, sir – What do you mean you can't write? Oh, I'm not able to write. How d'you get this far today? Oh, I came by bus.

Another feature was wanting to be seen to be the teacher, which arose for several participants. When Kathryn professed a disliking for team teaching (December AL set) she didn't want 'to be put in a situation where I'm not deemed as the class teacher'. Similarly, in January, CM referred to not being seen to be the real teacher, because he had spent time observing classes before teaching them. And in December, Zoe's class had asked her whether she was a real teacher when she had set out her expectations.

Furlong and Maynard (1995:81) also note that, at this stage, 'student teachers appeared to be consumed by a mixture of fear, anger, frustration and exhaustion'. The participants who exemplified this most strongly were Dean, Rachael, CM and Paul. Dean, for example, clearly experienced strong feelings about his classes in December. He said that he hated two of them. He felt very frustrated with himself for not being able to put his CBM strategies into practice. He felt that his practical lesson with Year 11, where there had serious safety issues, had been chaotic (4.3.3). In January, he was frustrated about the class in which pupils would not answer oral questions.

We also saw that Rachael expressed her feelings frequently in the autumn reflective journal (4.3.2). Concurrently, CM referred very negatively to some of the difficulties he had faced in teaching, using terms such as 'failed', 'futile' and 'rife'. Here, I might add 'depressed' to the list of feelings that Furlong and Maynard proposed. In fact, Malthouse and Roffey-Barentsen (2014) acknowledge that a limitation of reflective practice is that if one is repeatedly reflecting on unsuccessful teaching, there is the potential for this to be depressing. Additionally, during CM's description of the incident in which Brian was talking back to him (5.6, he said 'and at that point you just think, dare I say, I just want to clobber this kid', suggesting that CM felt very angry. We have already seen (5.6) that CM and Emily expressed fear.

Furlong and Maynard (1995) further suggested that PSTs' planning tended to be for class control, rather than for educational reasons *per* se, at the *Personal Survival* stage. Whilst Connor appeared to be a little further ahead than other participants in terms of implementing the school behaviour policy, there were a number of items in his December reflective journal that suggested his teaching strategies were designed to control behaviour. Examples include:

- 'Have some questions or an activity on the board to give them something to do as the kids walk in.
- Don't wait for kids to catch up, just move on.
- Even when doing a fun activity, everyone has to be doing something.'

Indeed, it appears that this was an approach that Connor was encouraged to adopt, since his mentor's comment in the report at the end of the first placement was 'Connor needs to… ensure that students are always engaged and occupied'.

Furlong and Maynard (1995) suggest that another feature of this phase is PSTs adopting the class teacher's style. I did not observe this in my data, and in fact Paul appeared to think this expectation was the other way around. In his December AL set, Paul felt as though he was being asked to conform to teaching in the same way as one of the class teachers with whom he worked, rather than actively seeking to emulate the class teacher:

> One teacher is very loud and expects me to be like that. But that isn't really my way as I'm more chilled and relaxed.

Overall, participants were concerned about taking the risk of asserting their authority, class teachers were sometimes reticent about handing over control, and participants were tested by pupils. Participants wished to be seen to be the real teacher. They had difficulties developing classroom control, such as in getting pupils' attention. They experienced strong feelings. Where they began to develop classroom control, this was sometimes achieved by designing teaching activities to control behaviour.

6.3.3 Stage Three – Dealing with Difficulties

Again, there were a number of examples that were in line with Furlong and Maynard's (1995) description of the *Dealing with Difficulties* stage. Some

participants began to gain classroom control. They appeared to feel under pressure to impress colleagues, and to be upset by their criticism. They sometimes seemed concerned about their performance as a teacher, for example, thinking about giving clear instructions and developing questioning.

As the course progressed some participants expressed more confidence than they had done in December – perhaps Kathryn (January) and Zoe (April), in particular. For example, when Zoe reviewed her action plan in January, she wrote:

> Pupils became more used to my teaching style – they recognised when I was waiting for quiet and acted accordingly.
> Trying to raise my voice over a class isn't needed.
> Keep expectations constant and make clear to students when they are/are not meeting them.

However, where Furlong and Maynard (1995) suggested that their PSTs adopted teaching styles that were designed to control pupils, some of my participants adopted other approaches. Kathryn appeared to have used a pupil management approach in which she had developed 'class-built expectations' with her Year 7 class (February, written review of action plan). This is an approach in which expectations are openly negotiated with pupils (Pollard, 1985). Such approaches are less controlling, since expectations are not imposed by the teacher exerting their power over the pupils. Zoe, too, seemed to have found a solution that did not require her to be more controlling (Apr review of Jan action plan). Her teaching issue had been pupils wandering around the classroom. Rather than imposing seatwork, Zoe had adopted more active teaching approaches 'letting students take control of activities and learn independently'. Furlong and Maynard (1995) might characterise these as a means of reconciling a wish to have warm relationships with the pupils with the need to have order.

Wanting to impress other teachers is best exemplified by Paul. In his December AL set, in which he was concerned about having too many targets, he was keen to demonstrate that he was taking on board teachers' advice, and to show that he was being proactive and reflecting on his teaching. Dean asked him what was the worst thing that could happen and Paul responded:

> Everyone hates me. I go to apply for a job there and they don't want me because I didn't listen to them when I was a trainee.

As noted previously, Kathryn described crying when she was given feedback by a teacher, and needing to develop a thicker skin, suggesting that my participants, too, were upset by criticism (4.3.2). Kathryn also mentioned concern about her tutor visit in the December reflective journal:

> Tutor X came. I was very apprehensive beforehand. Although my mentor had helped me plan the lesson and I was prepared, it was still very stressful.

According to Furlong and Maynard (1995), another characteristic of the *Dealing with Difficulties* phase was to focus on teaching strategies and classroom organisation, rather than on what makes teaching and learning effective. Examples within the data may include:

- Concern about questioning (Dean – January AL set; Rachael – April AL set)
- Needing to organise pupils' working groups for practical work (Connor – January AL set; Rachael – January AL set)
- Needing to give clear step-by-step instructions for practical work (Rachael – January AL set), or clear guidance for completing an internet research task (Emily – January reflective journal)
- Focusing on timing and pace (Paul – January AL set), or task completion (Paul – April AL set)

There is a possibility, however, that Dean's and Rachael's interest in questioning suggests that they were beginning to think about learning.

There was only one notable difference between my data and Furlong and Maynard's (1995) suggestions for this stage. Furlong and Maynard mention PSTs' reluctance to differentiate, not wanting to upset children by making them aware of their differences. Perhaps owing to the time that has elapsed since their research, and changes education in England in the intervening period, there was evidence of participants differentiating from the beginning. An earlier example was CM adapting a lesson for a pupil with ADHD (5.6).

Finally, Furlong and Maynard (1995) suggest that some PSTs blame the system, rather than taking responsibility, at this stage. Kathryn was most vocal in her criticism of the placement school, in the autumn reflective journal. I am not certain that Kathryn's criticism was unjustified, however. Where Kathryn was critical of the class teacher, it was because s/he had intervened in ways that Kathryn had found

undermining. She also said was dealing with large class sizes of up to 32 pupils, where there were too few stools. She said staff morale was low owing to a restructuring exercise that had taken place. Her experience was of 'no school policy' on CBM, which assuming there was a policy tends to suggest that there was an implementation difficulty. Meanwhile, Kathryn had attended a meeting with the headteacher, during which s/he appeared out of touch with the reality of pupils' behaviour. Kathryn also reported that the Year 10 group moved around to different classrooms, so it was difficult to introduce a suitable seating plan. The number and nature of these criticisms suggest a school (or science department) that was not functioning particularly well. However, by the end of placement, Kathryn appeared to reconcile herself to the situation:

> I was sad to leave placement A. They made me feel so welcome and they were supportive. There were issues within the school but I settled in well.

In this section, I have suggested that there were similarities in the development of the participants with PSTs in Furlong and Maynard's (1995) research. Some participants began to gain classroom control. They appeared to feel under pressure to impress colleagues, and to be upset by their criticism. They sometimes seemed concerned about their performance as a teacher, for example, thinking about giving clear instructions and developing questioning.

Overall, I suggest that my participants were slow to develop in comparison with the trajectory reported. Fuller and Brown (1975, cited by Furlong and Maynard (1995:76)) suggest that the *Personal Survival* phase 'may last for one or two *weeks*'. Furlong and Maynard (1995:92) also appear to suggest that PSTs were ready to move on 'to consider the quality as well as the value of what and how children learn' sooner than was observed for my participants. They wrote that this can happen 'after the first few weeks of survival and confusion, having now attained basic control, competence and confidence in teaching skills and strategies' (Furlong and Maynard, 1995:94). The data suggest that my participants were in the survival phase longer than that – certainly throughout the first placement for many of the participants (October to January), and on into April for CM. I consider a possible explanation in the next section.

6.4 Why might participants have found it difficult to develop CBM?

Furlong and Maynard (1995) argue that a determining factor in PSTs' success in developing CBM is the development of appropriate professional relationships with pupils. As described previously, they identify four dimensions to this development, which are *awareness of self*, *self-control*, *self-protection* and *satisfaction of self* (2.5.2).

Awareness of self

Within the dimension *awareness of self*, Furlong and Maynard (1995) suggest that PSTs need to set aside their early ideals. They state that this might be a particular problem for primary PSTs since primary school has an underlying ideology of child-centred-ness. This made it difficult for their PSTs to keep professional distance, since they were starting from a position of wanting to be the pupils' friend. My research data tend to suggest that this may not be substantially different for secondary PSTs. This finding is in line with Bromfield's (2006:189) suggestion that secondary PSTs, too, start their courses with 'humanistic' and 'pupil-centred' views on the relationships they might have with pupils.

Arguably, Connor was a participant who did comparatively well in developing his CBM. For example, it was evident in his December AL set that he had followed the school behaviour policy and sent a pupil out of his class (4.3.1). Interestingly, in response to CM's comment about being a 'wants-to-be-liked type of guy' and needing to adopt a 'No more Mr Nice Guy' approach (6.3.1) Connor said:

> That's what I've tried to do. When you start out you don't really know how the behaviour policy works… but once you know it I think trying to be the mean teacher is a good thing to go for at first. And then once they've started to realise 'okay, he's not gonna take any [crap]' then you can go on to be the nicer teacher who does cool things.

Perhaps Connor's relative success with CBM can be attributed to being able to set aside wanting to be liked, at least for a period of time.

Additionally, Furlong and Maynard (1995) suggest that their PSTs had reconciled needing to assert power with their ideals of maintaining warm and caring relationships by looking for ways in which to motivate them. One aspect of motivating pupils could be considered to be the use of rewards and sanctions, and

this was one of the themes discussed by the research participants on a number of occasions, as described below.

Firstly, both Dean (4.3.1) and Kathryn questioned whether pupils were motivated by rewards. The first instance came in Kathryn's December AL set, where she was struggling with some disruptive behaviour in her Year 10 class, as well as with pupils not listening. She was asked if they had reward points in her school. She replied: 'They have credits… generally not respected in years 9 and 10. They don't care about them.' Kathryn did not appear to feel very positive about giving praise for good behaviour either:

> Where you, like, praise around…[a number of students in the class who are behaving/working well]. I've tried that. It doesn't fit very well with me. For me it's a back door approach. Like, that student who is being naughty has to actually have the mental capacity to notice what is going on around them. Inevitably most of them don't, so they have no clue.

She questions the benefit of giving praise to pupils who are behaving well as a means of bringing about good behaviour from all pupils, as she does not think that the misbehaving pupils will notice. There was a similar comment about rewards during Dean's January AL set (4.3.1).

Whilst Dean had success with giving out sweets, he said 'I don't want them to only answer a question if they're going to get a sweet.' Other objections included that 'it's not setting a good example for the sugar intake' (CM, April AL set); that it might not be financially sustainable for a teacher, and that children had rushed their work in order to get 'an edible prize', rather than completing it properly (Paul, April AL set).

Although Paul was more positive about using praise than Kathryn, there was some evidence that he, too, felt uncomfortable about it. When asked how enthusiastically he responded when pupils were working well, he responded:

> I'd be like 'Hey, good job. Well done.', you know, 'You're doing good work.' I'm not screaming. And [if I was] I feel like that might serve more to embarrass them. I just kind of say it in a calm manner 'Hey. Well done, man.' You know, 'You got that right'.

One participant, however, was able to come up with a solution that went beyond simply giving credits, sweets and praise. In Dean's AL set in January (where he was struggling to get pupils to answer oral questions in class), Connor recounted:

> If they were scared to give an answer I gave house points and then whoever got the most house points at the end would get a reward. The reward was choosing which organ to dissect in the next lesson. Instead of candy.

Connor's success here appeared to stem from the fact that he had chosen to reward pupils with something they actually cared about, rather than credits or merit marks. Participants who were slower than Connor to develop their CBM seemed to be reticent both about asserting their authority by laying ground rules and applying sanctions, and about giving praise and rewards. Where others found that their pupils were not very motivated by the reward system, Connor was able to use the reward system creatively, apparently to good effect.

The reticence of PSTs in using rewards was also observed by Reupert and Woodcock (2010). They attribute this to awareness of the risks – that that we might demotivate pupils who do not get rewarded; and that we might later demotivate pupils when rewards are no longer on offer (Donaldson, 1978). However, I do not think our PGCE course included material about motivation theory – so Reupert and Woodcock's suggestion may not apply to my research participants.

I suggest another possibility, which is that it may be another situation in which there is a mismatch between PSTs' ideals, and what is possible. Brophy (2013:11-12) suggests that 'most people…find the concepts of intrinsic motivation and flow to be appealing', where 'we tend to experience flow when we become absorbed in doing something challenging'. I suggest the participants wanted to appeal to pupils' intrinsic motivation because of their numerous references to fun, which suggest a somewhat romanticised view of school. Brophy (2013:1) expresses an idea with which I tend to agree:

> We can and should expect students to experience academic activities as meaningful and worthwhile. However, we cannot expect them to view these activities as "fun" in the same sense that they experience recreational games and pastimes as fun. Even when they find the content interesting and the activity enjoyable, learning requires sustained concentration and effort.

He goes on to suggest that we are unlikely to be able to create the conditions in which we can achieve intrinsic motivation and flow in a school setting, owing to multiple constraints, such as:

- Its compulsory nature, e.g. with an imposed curriculum

- The fact that we teach large groups, so we may not be able to tailor our work to the individual pupil
- The nature of the social setting means that pupils' failures are public
- Needing to grade pupils' work and report to parents

Briefly, Brophy (2013) suggests that teachers should focus on pupils' motivation to learn, rather than intrinsic motivation. Perhaps this is something we could have moved on to consider once participants began to think about pupils' learning.

Self-control

Within the dimension *self-control,* Furlong and Maynard (1995) suggest that PSTs need to remain calm and positive; and to overcome their discomfort about difficulties such as waiting for the class to be quiet. They argue that the cause of PSTs feelings of anger and frustration is the mismatch between their ideals and what they are able to achieve. The use of humour is one method that PSTs develop in response, however this was not seen in the data.

Opinions on the subject of calmness were divided in the current study. Both Paul and CM appeared to have been both praised and criticized for having a calm manner. During Paul's December AL set, when a teacher wanted him to be louder (6.3.2), CM summed this up by saying that a calm teacher might help to keep the children calm, but not being a commanding presence is a difficulty.

Some of the frustration and anger expressed in the data appears to have been very strong, as noted previously (6.3.2). Given that Baird *et al.* (1991) and Tripp (1993) had identified an affective component to teacher development, I wonder whether the course could do more to support them in managing their feelings.

In contrast with Furlong and Maynard's (1995) suggestion, participants were not seen to have a desire to control and dominate. Rather, they appeared in some cases to find alternative approaches, such as negotiating expectations with the class (Kathryn, February review of action plan).

Self-protection

Within the dimension of *self-protection*, Furlong and Maynard (1995) suggest that PSTs need to develop a range of strategies and a hierarchy of actions. My data

suggested that participants were slow to apply the strategies they knew, and were reticent about using the sanctions available to them (e.g. Dean's safety incident and Kathryn's challenging Year 10 group, 4.3.2). The descriptions of the difficulties here resonated with the findings of Reupert and Woodcock (2010). In their study, too, PSTs tended only to use lower-level sanctions, rather than the whole range of actions available to them. Reupert and Woodcock identify a need for PSTs to learn to be more proactive. However, they question whether the school placement is the right place for them to learn it, suggesting that schools, too, may be reactive and controlling.

Interestingly, two studies from Turkey made an observation about the attitudes of science PSTs towards CBM that seemed to resonate with my research participants' lack of action as well (Maskan, 2007; Savran & Çakıroğlu, 2003). Both studies had used a protocol which measured PSTs' attitudes across Martin *et al.*'s (1998) three dimensions of CBM, which were instructional management, people management and behaviour management. They found that science PSTs were relatively non-interventionist on the people management dimension, i.e. that they do not wish to control people to a great extent. It is a position associated with wishing to give pupils greater choice in the classroom, and greater responsibility for their own learning. Perhaps the same was true of my participants. For example, we saw Kathryn and Zoe adapting in ways which did not exert power over their pupils (6.3.3). Perhaps they had begun to develop workable solutions to managing their classes in a way that fitted with their attitudes towards people management.

Satisfaction of self

Furlong and Maynard (1995) suggest that once competence with CBM has been established, it is possible for PSTs to 'bring the personal back in' and to show the pupils that they are human. Perhaps an example of this within the data was the relatively easy relationship that Paul described with his Year 7 class, in which he was able to let his guard down to do an impression of Gandalf (4.3.1).

However, where Furlong and Maynard describe experienced teachers holding pupils in positive regard – trying to see the good in them – the participants did not appear to reach this stage. Having said that they wanted to have friendly working relationships with their pupils, they were quite negative in their language about their more

challenging pupils. Examples included describing pupils as 'horrible' (Kathryn, Dec AL set), 'miscreants and troublemakers' (CM, Dec & Jan AL sets), 'little shits', and 'smarmy-arsed [bastard]' (Dean, Dec AL set). My professional experience suggests that liking the pupil but disliking the poor behaviour is a better mindset. Dreikurs (2004) theory, suggests that pupils who present with the most disturbing behaviours, who may be the most difficult to like, are probably in most need of teachers' care.

6.5 Summary

In this chapter, we have seen that the participants' predominant area of concern was development of CBM. This observation is not entirely surprising in light of other research evidence about PSTs. However, there is a possibility that my participants were slower to develop than might have been expected, since others had suggested that basic competence might be achieved in a few weeks.

CM, who decided to leave the programme, appeared still to have been struggling to develop his CBM practices in April, and perhaps Paul was also still developing CBM at this point. The evidence tended to suggest that most participants were in the early stages of Furlong and Maynard's model (perhaps the *Personal Survival* phase, in particular) throughout their first school placement.

An SQ was:

- Why might the participants have found it difficult to develop CBM?

A possibility was that Furlong and Maynard (1995) suggested that developing appropriate working relationships with pupils underpins development of CBM. Many of the participants appeared to find it difficult to assert their authority. It is possible that they found it hard to set aside ideals about the warm and friendly relationships with pupils that they wished to develop. Additionally, there appeared to be some reticence about using rewards to motivate pupils. It is possible that Connor was relatively successful with his CBM because he was able to recognise the possibility that he could start off as the 'mean teacher' and be the 'nicer teacher' later. He was also able to use the school reward system creatively. Some participants were able to develop strategies that may have been in tune with a desire to be less controlling.

Overall, if the slow rate of development of science PSTs' CBM is a widespread problem, going beyond the small group of participants in the research, then it needs further consideration if we conceive of our role as developing strong science teachers. Perhaps the development of CBM needs to be addressed differently if we are to support science PSTs in making better progress.

In the following chapter, I move on to evaluate the success of the teaching intervention. I used the DTC (Tripp, 1995) together with AL (Bayley, 2015). The intervention was intended to support the development of science PSTs' teaching. Aubusson *et al.* (2009) suggested that AL consists of four parts – *reflection, community, action, feedback* – each of which is underpinned by theoretical ideas about how teachers learn. I evaluate the intervention in terms of these four areas, including the views of the participants; and my own view as a course tutor and researcher; and discuss the extent to which the processes achieved what was suggested in the literature.

Chapter 7. Evaluative analysis of the teaching intervention

7.1 Introduction

In this chapter I evaluate the extent to which the teaching intervention worked to support participants' development. The relevant RQ is:

- How well did the teaching intervention work to support participants' development?

As noted previously, we know the end of course outcome formally for only four participants (5.6). Zoe and Emily passed with 'outstanding'; Paul passed with 'good' ; and CM withdrew from the course in April. Because CM did not complete the course successfully, arguably the intervention was unsuccessful. The DTC and AL, as implemented here, were not a magic bullet. Emily, Paul and Zoe did very well in terms of the final assessment of their work against the TS (2011). However, we cannot necessarily infer that the intervention was successful, since the number of participants concerned is only small. There may also have been a greater likelihood of those who attained 'outstanding' (or otherwise strong) grades contacting me with this information at the end of the course. We also do not know how these participants would have done had I not used the intervention.

For the remaining four participants, there was some evidence that they had made progress in overcoming their teaching issues, both from their own oral or written feedback about their action plans, or from their mentors' Teaching Reviews or Reports during their first placement. However, again, we do not know how their progress compares with PSTs who were not exposed to the intervention, nor whether it was the intervention that led to progress.

So how can we evaluate the intervention?

Aubusson *et al.* (2009) suggested that AL is based on four processes by which teachers learn – *reflection, community, action and feedback* (2.4.2). In this section, I discuss these elements, using examples from the data, to consider the extent to which AL worked in the way that was suggested to support participants' development. I consider participants' views, and my own view as course tutor and researcher, comparing my implementation of AL with that in other studies, where relevant.

There was a limited amount of data about participants' views of AL. Relevant seminars always included a final step 'The whole group will then review the process. What did we do? How did we do? What did we learn?'. However, neither December AL set carried out this step, and nor did the one in February. So participants' views come from January and April AL sets. That said, they made some salient points.

7.2 Reflection

The project included two elements intended to be a vehicle for reflection – the written analysis of critical incidents, and discussions in AL sets. I begin this section by considering each of these elements. Although I have already discussed participants' reflectivity in chapter 5 there is one further point I consider, based on my analysis of the data. Aubusson *et al.* (2009) suggested that one of the benefits of working in a group, rather than working individually, was that input from third parties can be helpful to challenge the underlying assumption of the person reflecting. Hence, in the second part of this section, I consider the evidence for *Dimension 4 Question your personal theories and beliefs*.

7.2.1 Tutor and participant views of critical incidents and AL sets

My intention was that reflective journals would form a critical incident file (Tripp, 1993), which would inform critical incident analysis and the choice of teaching issues to discuss in AL sets. Unfortunately, only five of eight participants produced a reflective journal, which is not a very good completion rate. Only two participants continued to write reflective journals into the spring term. Anecdotally, this was because participants found writing journals too onerous alongside their other work.

Where reflective journals existed, they often produced an overwhelming amount of material. Little time was available in university sessions to reflect on their content, and hence they may not have been used by participants in the way that was intended. Additionally, journals were not always very reflective. For example, Connor's autumn journal consisted of a list summarising what he had learned about teaching (Appendix U). Whilst this activity might be considered reflective in the sense that there is evidence of Connor thinking about his teaching, a more reflective account

might consider different viewpoints, or perhaps be more critical, evaluative or interpretive.

On the other hand, I found the reflective journals very illuminating as a course tutor. I now have a much better understanding of some of life's realities for science PSTs. Because journals often recorded material over days, or weeks, or several lessons, I have a much greater insight into PSTs' experiences.

For example, I had always been aware that developing CBM was a significant issue for PSTs, but perhaps not to the extent that became apparent upon reading their journals and listening to the audio recordings. This knowledge encouraged me to make an adjustment to my teaching, adding a session about CBM for my tutor group, which may have been of some benefit.

Perhaps, overall, journals were more helpful to me than they were to the participants, as implemented in this study. I would need to consider how to use journals more effectively, if using them again. It might work better if the journal was a course requirement, as it is on some courses (noting, for example, that the Teach First course has one), since completion rates might then be higher. However, PSTs should then do less of something else, so as not to increase workload. More dedicated time would also be needed in university, in which PSTs could work with one another and their tutors to discuss the content of journals and to develop some of the occurrences into critical incidents via analysis, as I discuss below.

Generally speaking, PSTs did not write much in their critical incident analyses in our seminars. At the lower end in length, in December, Kathryn's contribution was limited to six words (4.3.2), and at the upper end, Rachael and Emily filled about two-thirds of a sheet of A4. Additionally, participants tended to write bulleted lists, rather than continuous prose, which may link with their academic backgrounds as scientists and engineers. Their writing was also not very expressive.

I suggest that there were at least two difficulties here. Firstly, perhaps not all science PSTs are confident with writing prose. Perhaps if they had been more confident writers they would be training to be English or history teachers (since these subjects may demand more extended writing, both at A level and during undergraduate

courses). Secondly, given the amount of material I attempted to fit into the December seminar, it is unlikely that more than about 20-30 minutes were devoted to writing. I do not think this was enough time for the PSTs to complete the task. For example, Zoe's journal in the autumn term was quite lengthy and detailed – which tends to suggest that she was a capable writer – however, her December critical incident analysis was limited to two paragraphs describing two teaching issues she was experiencing. CM and Paul also wrote relatively short accounts that were descriptive, rather than reflective. However, Dean, Rachael and Emily did attempt to apply some of Tripp's strategies (4.3.2, Tripp, 1993, Appendix D).

There was a slight improvement in the written critical incidents completed in January, at least in terms of quantity. Everyone who handed in a contribution wrote at least half a side of A4 paper. Connor explicitly attempted to apply some of Tripp's thinking strategies to the task and Paul's writing now went beyond being purely descriptive. Perhaps this improvement is accounted for by the fact that I had allocated a little more time in the January seminar than in December. I am uncertain that there is much evidence that the additional teaching I did about reflective writing based on material from Moon (2013) had any impact, however (4.2.1).

Overall, I do not think written critical incident analysis was a particularly successful approach in this intervention. If I was to do it again, I suggest using it more frequently, to support PSTs in developing confidence with writing. More time and attention would also need to be devoted to improving the quality of reflection. I am not certain that there is sufficient time available for this activity in the context of a PGCE. This is not to say that I do not think that developing reflection is important, however. In an ideal world, perhaps written critical incident analysis would form part of a longer-term course of professional learning, extending into the NQT year and beyond.

As a means of getting science PSTs to reflect on their teaching issues, I suggest that AL sets were more successful than written journals and critical incident analyses. Where some appeared to find it difficult to write, they had little difficulty in talking about their teaching. However, there was debate amongst the participants about the usefulness of being asked to reflect. In the January AL set, Rachael was the lone

voice that seemed to be in favour, saying 'I think this process of discussion and reflecting for me is really useful'.

At that stage, PSTs had a preference for obtaining advice about how to overcome teaching issues, about which there was general agreement between Paul, Dean, CM and Zoe – an attitude perhaps best summed up by Paul:

> My criticism of the process is there's not much opportunity for providing suggestions because I think the way you solve a problem in your classroom is you try lots of different things and then when something works you stick with that, and if it stops working you try something else. It's good asking the questions and getting them to reflect themselves on it, but I felt that it's getting all of these ideas from people you know and then trialling them.

Zoe appeared to agree – 'I just want that bank of ideas'. Perhaps at this relatively early stage in the course, participants were learning to teach by a process of trial and error.

However, by April, both Paul and Zoe appeared to have joined Rachael in being positive about reflecting. Paul commented:

> I think it is quite useful, the open non-leading questions, as long as the purpose of those is to try and make you think about it deeper, or in a way you haven't, potentially, thought about it – without trying to lead them to what your own, kind of, preconception of what the answer should be. It is a difficult thing to do, but I think when you do do it, it is quite effective.

That said, Zoe suggested that it would have been helpful if there had been 'a slightly bigger list of questions', since she had found herself asking the same four, and had found it difficult to think of her own open questions (Appendix F).

Although CM enjoyed the sessions, and although he said that they helped him with reflective practice, he was less positive about open-ended questioning.

> Yeah, it is a bit limited with the questions that we have here. Let's just look at a random question - 'What would you do differently? "I don't know, that's why I'm here."

So perhaps CM was still looking for the bank of suggestions from others at this point.

I now wonder whether Malthouse and Roffey-Barentsen's (2014) suggestion that science teachers are not very reflective stemmed from the fact that their study relied

to an extent on written contributions. Perhaps science teachers are not very good at reflecting in writing, as opposed to not very good at reflecting.

7.2.2 Questioning assumptions

The intervention was not particularly successful in supporting participants in questioning their assumptions, linked to the fact that there was little evidence for *Dimension 4 Question your personal theories and beliefs*, as noted in the heatmap (5.3). There were a number of assumptions that went unchallenged, notably about the reasons for pupils' misbehaviour and the 'abilities' of pupils, as I will discuss.

Various parts of the AL sets suggested that participants made assumptions about why pupils behave in the way that they do. In the December AL set, for example, during Connor's teaching issue about a pupil who had 'shut down' and was refusing to work, participants discussed possible reasons for the pupil's misbehaviour, which included whether he had ADD or dyslexia. Another example was CM's reference (January AL set) to Year 9 pupils misbehaving because their 'hormones kick in' (5.6). Additionally, when Emily discussed her concerns about moving from her placement in an independent girls' school to a mixed state school, she referred to the former as having 'no rowdy boys, certain demographic, higher-achieving girls'. For me, this suggested potentially unhelpful stereotypes about differences in the behaviour of children of different genders, as well as assumptions about how poor behaviour might be linked to children's socioeconomic background, or to their level of attainment (5.6). Similarly, in discussing her difficulty with the behaviour of her Year 10 group, Kathryn recounted a conversation she had overheard, which had taken place between some other teachers, in which they had said 'The parents aren't particularly supportive of schooling and didn't have great schooling themselves', by way of explaining the pupils' behaviour (December AL set). One might say that participants had a deficit model about reasons for pupils' misbehaviour.

Of course, there may be an element of truth in these suggestions. However, the point I wish to make is that we did not see other participants asking relevant questions to help them consider different viewpoints. Questioning these assumptions might have led to an improvement in their teaching, since they may have considered whether pupils' behaviour was related to the lesson itself, rather than outside of participants' control.

The second theme I wish to raise is participants' references to pupils' abilities, sometimes overlapping with concerns about behaviour, as described above. The reason for raising ability is because of its ubiquity across the data. Some examples include:

- Where Paul was having difficulty managing his Year 10 group, Dean asked him whether he had a better rapport with another class because they were 'high ability' (January AL set)
- Rachael's group with the girls doing one another's hair were 'low ability' (December AL set)
- Both Kathryn (December AL set) and CM (January AL set) expressed surprise at the way their 'top set' (Year 10 and Year 9, respectively) presented – CM, for example, said 'supposed to be top set Year 9 class, but you wouldn't believe it', and later in the same episode 'But this Year 9 group, who should be top set and should be quite high-achieving'…, and further 'I would have expected more from a top set Year 9, to just shut up and get on with the task'.
- In the context of Zoe's AL set about having to wait for her class to be quiet, Connor began his suggestion about how to deal with the situation with 'something I do with my Year 10s who are very chatty, but they're really good – it's top set…' (December AL set)
- In Dean's AL set about his difficulty with a quiet class, he explained that 'they were a top set class'. In making a suggestion about how to tackle the issue, Connor stated 'I've got a class similar to your class in that they're top set…' (January AL set)

As an observer of what appeared important to the participants, it was interesting how often they offered information about pupils' ability (or whether they were in top set) when describing the context of their teaching issue, or how often they asked one another questions about the pupils' ability. With the possible exception of issues concerning how to deal with mixed ability groups, from my perspective, bringing the concept of ability into the discussion did not add anything to our understanding of the situation, nor how we might tackle it.

From the standpoint of a course tutor, if children have different abilities we need to assess what they are able to do and what they are not able to do, and then plan to support them in being able to do in the future what they cannot do today. Top sets may vary widely, both within and between schools since they have varying intakes. Pupils' abilities may be very different across different areas of science, or different types of tasks. Blanket statements that they are top set or low ability are unhelpful. At worst, teachers' assumptions about pupils' abilities may produce self-fulfilling prophecies.

Perhaps it is expecting a lot of PSTs to question their assumptions about ability, or about what top set should be like, given that we know that setting and streaming are common practices in schools in England. However, it does concern me insofar as we know that research evidence suggests that setting and streaming are detrimental, overall, to pupils' progress (Francis *et al.*, 2017).

Overall, the open-ended questioning in AL sets did not enable participants to question their assumptions. This finding was similar to that of Plauborg (2009:31), who commented that '[teachers] often focused on solving practical problems… rather than challenging and taking a critical and reflective approach to one another's practice'. Perhaps, ideally, the AL set needed to include a more informed third party, so that assumptions that appeared to be widely shared by participants could be challenged.

7.3 Community

Aubusson *et al.* (2009) suggested that social interaction is important for teachers' learning, linked to Vygotsky (1978). In this section, I consider ways in which it appeared that participants learned by working collaboratively in AL sets. My analysis suggests that the discourse helped them in several ways. However, there were also some limitations, both in terms of the nature of the group discussions and in terms of constraints.

One positive was that discussion in AL sets enabled participants to see that they were not alone in dealing with particular teaching issues. There appeared to be general agreement on this point in both January and April, particularly from CM, Dean, Rachael and Zoe. For example, Dean said (January):

> It makes me feel better hearing that everyone is having similar issues. It's nice to know that I'm not the only one that's having behavioural issues, or interaction issues with your class, or the hesitancy to own that class.

Similarly, in April, CM said it had been therapeutic to talk to one another about it, which Rachael echoed, saying, 'I feel like I've grown closer to you all and this [the AL set] is the highlight of my day'. Zoe noted that although the process had been 'a bit negative' (since they were focusing on their teaching problems), she had felt better afterwards. CM referred to it as a '*Schadenfreude* type of thing' since they had felt better 'because of hearing about other people's misfortune'.

Writing about an AL project with qualified teachers, Plauborg (2009) notes that they can be quite isolated in their classrooms, and that they appreciate opportunities to meet with one another to discuss their teaching. Perhaps the same is true of PSTs.

Although the structure of AL sets originally suggested (Bayley, 2015) consisted purely of open-ended questioning of the presenter, participants tended to give one another advice. In Aubusson *et al.*'s (2009) model, members of AL sets were allowed to introduce new ideas. By April, I adapted the instructions for the AL set to incorporate advice-giving as a possibility, based on participants' feedback to me as a course tutor.

The audio recordings included numerous examples of participants adopting others' advice into their plans. Appendix Z summarises these. As noted previously (7.1) participants said they appreciated the opportunity to build up a bank of ideas in this way.

Similarly, the January AL set appeared to appreciate the opportunity to hear about difficulties from other participants that they had not yet come across, and to think about what they would do in those circumstances. CM noted that this was helpful because then 'you know what to look out for'. Dean said 'it's really interesting to see people coming up with ideas and thinking 'This is how I would do it'. Perhaps the AL set helped to prepare participants for situations they had not yet dealt with.

Whilst building up a bank of ideas may be perceived as being useful to them, it may also present a challenge. Loughran (2007) suggests a need for science teachers to

move from a position where they want to be told how to teach, to one where they want to learn how to teach. Perhaps participants who wanted to gather advice from others had not yet made this transition. There is some resonance here with Malthouse and Roffey-Barentsen's (2014) suggestion that science teachers are positivists, or are thinking in terms of basic dualisms. It tends to suggest that they may still think that there is a right way to teach – that they just need to gather the right ideas.

Plauborg (2009:31) also observed a tendency for teachers to wish to expand 'their repertoire of ideas' in AL, rather than to critically reflect. Perhaps, then, this is a weakness of AL.

Both the second AL set in December (Emily, Kathryn and Rachael) and the February AL set (Emily and Kathryn) tended to follow the protocol of asking questions, rather than making suggestions. That said, as Paul noted (7.2.1), even when participants asked questions, there was a tendency for them to be leading questions. Some of the leading questions also suggested courses of action that the presenter might take, which were adopted into their plans, i.e. the purpose of the question was really to give advice. For example, in the context of developing Emily's CBM, Kathryn asked 'Could you do role-play with anyone?' and Emily responded 'Good idea. I'll use my sister to practice beforehand'.

Another purpose of some of the more leading questions was to encourage or support the presenter. I think these questions served a very useful function. They often arose in situations where, arguably, the presenter's expectations of themselves seemed unreasonable. The consequence of this questioning was that the presenter moderated their view. A good example of this type of questioning appeared in Connor's January AL set, in a discussion about dealing with two girls who had fallen out with one another and who were now refusing to work together. CM asked 'What could you do to try to help that, or is it beyond your control?'. I suggest that CM was inferring that it was beyond Connor's control. Connor's response revealed that an experienced teacher and a TA had attempted to resolve the situation, without success. Paul's follow-up question was 'What could you do in terms of your lesson, without addressing the whole situation going on, make it successful?' which focused Connor on what was achievable by him, as PST. In the subsequent discussion, Dean prompted with the question 'Do they sit near each other?', which revealed that

Connor had moved the girls apart. Zoe subsequently interjected with 'Does this all need to be dealt with by you or are there other people who could help you with this?', which led Connor to realise that the Head of Year could deal with the wider issue. Connor concluded that:

> I shouldn't worry too much about the problem as a whole as it's quite difficult and it is something that will happen occasionally, and the only thing that will fix it is time. But to resolve it in lessons and make sure that the lessons continue going on the way they should, moving them is a good idea.

This seemed to me to be a reasonable outcome, and I suggest that this was a benefit of this type of group discussion.

In an AL project with nurses and teachers in the UK, Stark (2006) also noted that group members tended to be supportive of one another. However, she also found that group members were reticent to be critical of one another, which may have meant they did not challenge each other sufficiently. In contrast, in some AL sets in this study, leading questions did serve to challenge or push the presenter. For example, in Kathryn's AL set in December she was struggling with CBM with a challenging Year 10 class. Kathryn said that her routine for getting quiet with them was 'hollering at them and being grumpy. Moving them when they're not responding'. Emily asked whether the pupils were receptive to hollering and whether there was any follow-through. I infer that Emily thought that hollering was probably not likely to be a helpful approach, and that Emily thought Kathryn might do more to follow up. Kathryn admitted:

> So far I haven't given any of them any detentions or any sanctions whatsoever in Year 10. I haven't felt it necessary to do as yet. I can get them back. I can get them so they are silent.

The line of questioning then asked 'Would it not waste less time in the lesson if you gave some detentions?' and further asked what Kathryn wanted to achieve with the group. She responded that she would like a little more respect from the boys, to which the follow-up question was 'Why do you think you have not established that respect?'. This line of questioning seems fairly robust in suggesting to Kathryn that she could do more to manage the situation. Her conclusion suggested that she had taken this on board. Rachael asked 'What are you going to do now?', and Kathryn responded:

> Be more firm. In an ideal world re-do a seating plan but it's one lesson in a different room. Be more on top of their behaviour. Move them if they are insolent. Give out detention for that student.

Perhaps challenging feedback is better delivered by peers than by mentors or tutors. Perhaps there is a greater likelihood of PSTs acting upon their peers' suggestions.

Finally, there were some examples within AL sets of participants using genuinely open-ended questioning, although, as Zoe noted (7.2.1) often based on the examples provided (Appendix F). And despite some participants expressing the preference for getting others' advice, they were all always able to come up with a solution themselves. Hence the AL set met one of its original claims, which was that 'it facilitates you as mentees forming your own strategies to work through an issue' (Bayley, 2015). In Rachael's AL set about the need to develop her questioning, for example, Zoe asked 'I hate this question but if you take more risks, what's the worst thing that might happen?'. Rachael responded:

> That it doesn't work. The worst thing that could happen is that it doesn't work and I don't use that strategy again. And maybe I need to do options as well, give them – we can do it this way or we can do that way. But I think having the questions written down, and looking up AfL strategies as well in books, and remind myself of the PD [professional development] sessions we went to before.

In this instance, the open-ended question enabled Rachael to think of some possible solutions to her own problem. The question 'What's the worst thing that might happen?' was perhaps surprisingly helpful. It also seemed to serve the purpose of making participants realise that their teaching issue was survivable, or possibly not as serious as first thought – that it could be overcome.

I suggest that the open-ended questioning, where it happened, also served another function, which was to reveal more about the thinking of the presenter to the group, and possibly to themselves. A good example was from Dean's AL set (January) about a quiet group who would not respond to oral questioning. Dean had originally framed this teaching issue in terms of the lack of response 'killing the pace' of the lesson. However, part-way through the AL set, CM asked him one of the exemplar questions, 'How important is this to you?' and he responded:

> It's getting some kind of feeling of engagement. "How is my lesson going? Are you understanding what I'm talking about?" Because, other than that, it ends up my just looking at their books, where either they've just copied

> something off the board, which obviously they're going to get right, and all I can write is 'good notes', or it's questions that I've asked them, and then gone through, and they've written the correct answers. And I can't see how much they've been able to do themselves. I've got no kind of knowledge of where they are until they do a test, and either they do really well, or they don't. There isn't anything in between. I don't know if we're going to be doing assessment again at a later date, but there was no way of me telling where they are and if they understand during this lesson because there was no interaction at all.

This was significant because it revealed that the real concern was not about 'pace' or 'engagement' – Dean actually wanted to be able to get feedback from the pupils about what they had learned or not learned. Arguably, clarifying the issue in this way enabled participants to generate more apt solutions.

I have suggested that participants did not question one another's assumptions (7.2.2). In some AL studies (Plauborg, 2009; Stark, 2006) a consultant or academic partner takes part in the group discussion, i.e. they perhaps take a fuller role in the learning community. Perhaps if I had taken part in the AL sets, I would have been able to facilitate greater criticality. That said, Stark noted that there was a tendency for some AL groups to be overly dependent on the facilitator. I also note that if I had been present in my role as course tutor, there was the possibility of influencing what participants felt they could say. So a possible benefit of not taking part in the group was that they were freer to express themselves. Additionally, this would not have been feasible across the whole group of 38 science PSTs.

In terms of developing community, another limitation of the study may have been the instability of the groups in the AL sets, since I was unable to ensure that the same people worked together each time. Several studies emphasise the importance of using the same group of participants to develop trust (Hoban *et al.,* 1997; Aubusson *et al.*, 2007; Stark, 2006). Stark (2006) had a similar difficulty to me, in that some of her participants lacked the time to attend AL sets, which was the reason some of my participants gave for not attending the April AL set. Aubusson *et al.* (2007) also point to needing to have sufficient time available in order to implement AL properly, which I think was a difficulty during an intense PGCE course.

In several other studies, AL sets were more regular and frequent than I was able to achieve in this study, noting that Baird's (1992) participants met bi-weekly. This

may also have helped them in establishing learning communities, and is something that I would like to do if using the approach again. Similarly, other projects were carried out over a longer period, whereas my data were limited to part of one academic year. Perhaps more could have been achieved in terms of developing participants' teaching had I carried out a longitudinal project over several years.

Overall, the community element of AL enabled participants to:

- Share their personal experiences with one another, which was therapeutic
- Make suggestions to one another about how to tackle their teaching issues, both directly and by asking leading questions
- Support and encourage one another, for example by helping them to moderate their expectations of themselves as PSTs
- Challenge one another when they thought there was more that they could reasonably do to tackle their teaching issue
- Consider their own solutions to their teaching issues, where questioning was open-ended
- Reveal more about the nature of the teaching issue, leading to more apt solutions

7.4 Action

Aubusson *et al.* (2009) suggested the Kolb cycle as a theoretical underpinning of AL. The processes of producing an action plan and attempting to implement it fit in with both Tripp's DTC (Tripp, 1993, Fig.2, p.40), *Plan a response* and *Implement a* response, and Kolb's (1984) *Active Experimentation* phase (Appendix G).

Discussions in AL sets generally enabled participants to write action plans setting out how they intended to overcome their teaching issue. (Unfortunately, not everyone handed them in.) Rachael gave positive feedback about this aspect of the process (January AL set):

> And actually, we've got [different ideas] in our head, but sort of formalising them and writing them down, so we need to go over them and do something about them. So that we're actually taking them forward into the next placement…

Although this feedback was from only one participant, it does tend to support the use of the process at regular points through the course. Written records appear to have

helped Rachael in keeping track of action she planned to take. Hence I think there is the potential for the process to support PSTs in developing their teaching in a sustained way over a period of time, which Dillon (2000) had suggested was one of the conditions for effective science teacher development. However, there was a limitation in the present study.

In an ideal world, I would have liked to have been able to make a greater contribution to the PSTs overcoming their teaching issues, drawing on my expertise as a science educator. I note that Bell & Gilbert (1996:34) pointed to the need for 'input of new theoretical ideas and new teaching suggestions', as one of the conditions for science teacher development. I was troubled by participants' lack of reference to material from the taught course in discussions of their teaching, including lack of reference to theory.

I wonder whether the difficulty arises because at the point at which some of the material about teaching is taught, it is not yet perceived to be relevant by PSTs. Until they gain experience of teaching in school placements, perhaps they are not yet able fully to appreciate the challenges of teaching. I note that another condition suggested for science teacher development was dissatisfaction (Dillon, 2000). Perhaps it is not until they experience teaching issues in their school placement that they are ready to engage with relevant material. To use the language of Kolb, perhaps they need to have *Concrete Experience*. I think it is possible that the limitation of lack of tutor input, as well as the issue of the timing of theoretical input, could be overcome with an extended period of action planning, as I describe further in *Implications for Policy and Practice* (8.5).

Whilst the data often suggested that participants had been able to take action to overcome their teaching issues, there were some instances of them not taking action, as I describe below:

In Emily's case, she chose to talk about CBM at a time when she did not have a difficulty with it, owing to the nature of her school placement (December and January). It is understandable that she perceived not having a problem with CBM to be a problem at a time when others had many difficulties with CBM. However, it would have been better if she had focused on something that was affecting her at that

time, so that she could take action to resolve it. So if I was using AL with PSTs again, I would encourage participants to focus on teaching issues that are current, rather than ones they think will be an issue in the future.

In the case of developing CBM, some participants (notably CM) seemed to be stuck. I further note that the structure of the course may have led to a lack of action on CBM from some participants – they seemed to be reticent about taking action in December because the end of term was approaching, and in January because the end of the placement was approaching. One example came in CM's December AL set, in which he was discussing his difficulty with Brian. Dean asked him 'Have you fiddled with the seating plan?' CM replied:

> I'd like to do that in the New Year, but cos we're only there for two and a half weeks. But yeah it is my classroom. I would put him separately, sit him on his own.

Later in the same audio recording, when Dean was discussing his teaching issue about a challenging Year 11 group, they revisited this suggestion. Dean said that he was aware that he needed to change the seating plan for this class, and CM responded 'It's too late to do one now.'

Connor, however, appeared to have a more positive attitude as to how to use the remaining time available. In response to CM, he said:

> Think of placement A as a chance to experiment. Try out being 'the really mean teacher' with them and after a few weeks you're done and you can walk away and not have to deal with them anymore.

I make some suggestions about developing CBM in Chapter 8.

7.5 Feedback

Aubusson *et al.* (2009) suggested a range of material that could be used in feedback (2.4.2). In the AL seminars, I suggested a slightly more limited range of material that might show evidence of participants' progress in overcoming their teaching issues, which were samples of children's work; lesson evaluations; field notes on their lesson plans; and mentor meeting logs.

In the event, feedback was more limited. Participants provided self-reported feedback orally in the AL sets, and through written reviews of their action plans.

Additionally, there was feedback in the form of mentors' written reviews and reports of participants' progress in school. Not all of these elements were consistently completed or provided by participants, which is a limitation. (Data collected are detailed in Appendix L.) This fact explains participants' low levels for *Dimension 2 Systematically evaluate your own teaching through classroom research procedures* in the heatmap of reflectivity (5.3).

I was able to find only one other example of researchers using AL in ITE. Working with final year undergraduate PSTs in Australia, Penney and Leggett (2005:160), too, found that:

> Having identified a personal professional issue as a focus for their projects, some students have …struggled to see how they may 'research it' in the required systematic, structured way, collecting specific 'evidence' or 'data'.

They suggested that PSTs needed more help to understand what counts as data. Indeed, on reflection, my own PSTs might have benefited from additional teaching about collecting research data.

Interestingly, Penney and Leggett's AL process was a core requirement of a course module. My own AL process, in contrast, was not really integrated into the PGCE. It is possible to imagine a PGCE module involving participation in a number of cycles of AL, collecting evidence, and reporting back. Perhaps making it a course requirement would help to raise the status of data collection, and might also ensure that more PSTs completed reflective journals. That said, Biggs and Tang (2007:37) point to the need to 'ensure that academic activities are meaningful and worthwhile', rather than forcing completion.

Other AL projects working with experienced teachers included feedback in the form of structured peer observation (Plauborg, 2009; Aubusson, 2007) or feedback from pupils (Hoban *et al.*, 1997). I have, in the past, given opportunities to PSTs to visit different placement schools to complete peer observation, and to give feedback. Peer observation has also been used successfully in ITE in lesson study projects. (See, for example, Lamb, 2015.) If using AL again, I would like to explore peer observation as a vehicle for obtaining feedback on PSTs' progress, as this seems to me to be feasible.

Using pupil feedback may be more problematic. Hoban *et al.* (1997:49) carried out a 3-year project in a high school science faculty with experienced science teachers. They recorded interviews with pupils about their views of their learning experiences in science and what teachers might do to 'influence these experiences'. Teachers found the feedback challenging. Given that several of my research participants struggled with feelings of frustration about their teaching, I am not certain that feedback from pupils would have been helpful, as it may have damaged their confidence.

Later in their project, Hoban *et al.* (1997:54) asked pupils to complete learning logs instead of audio recordings, because there had been an overwhelming amount of data. Pupils wrote about what they had learned and 'teaching strategies that helped them to learn'. This approach might be an appropriate activity for a PST once they have begun to consider pupils' learning. In the current project, that might have been from April onwards.

Noting again the need for teachers to be dissatisfied in some way in order for development to occur (Dillon, 2000) perhaps better feedback could lead to more action, where it was lacking. Hoban *et al.* (1997) note that pupil feedback was a catalyst for change.

7.6 Summary

In this chapter, I have evaluated the teaching intervention, looking at participants' views, and my own views as a course tutor, of the four elements of the AL process.

PSTs gave feedback about AL via oral reviews in AL sets. They appreciated the opportunity to share their experiences. The use of action planning may have helped them to keep track of their progress over time. They found it helpful to hear about situations they had not yet come across, as they felt forewarned. They were particularly positive about having opportunities to learn from one another's suggestions about how to overcome their teaching issues. Some participants found the open-ended questioning to be helpful in developing reflectivity.

As a course tutor, there were some challenges in asking PSTs to write. Journals were helpful to me in understanding the difficulties PSTs faced. However, perhaps they need to be a formal part of the PGCE course in order to support completion, accompanied by a reduction in PSTs' workload elsewhere. I did not find asking PSTs to write critical incident analyses to be very successful, preferring AL sets. For AL sets to be even more helpful, I would have liked them to be more frequent, and to take place throughout the PGCE course. I would have liked to have had more input into their action planning in my role as course tutor – so that PSTs could better draw upon my expertise.

Although participants and I were fairly positive about AL, I was concerned that they did not question some of their assumptions. Most significantly, participants seemed to attach importance to pupils' abilities, an attitude which may confound attempts to close achievement gaps. Perhaps greater reflection could be encouraged by the presence of an academic partner in the AL set, although this may not be feasible with the whole group of PSTs.

Aubusson *et al.* (2009) suggested that the opportunity to work as part of a community was a strength of AL. My data suggest that participants benefited from social interaction in the AL set. Participants:

- Supported and encouraged one another, sometimes suggesting to them that they needed to be more realistic about what they could achieve as a PST.
- Challenged one another, when it appeared that there was more that they could do.
- Realised that their teaching problems were survivable.
- Understood their teaching issues better, which enabled them to arrive at concrete solutions.

In Chapter 8, I conclude the thesis. I begin by restating the purpose of the study, and then summarise the answers to the RQs. I reflect on what we have learned about the theories underpinning it, and consider its strengths and limitations. I consider the implications for policy and practice, as well as implications for future research, and the contribution of the study. I close with a personal reflection.

Chapter 8. Conclusions

8.1 Introduction

The project was inspired by a practical problem from my work with science PSTs, which was that they appeared to progress less well on their PGCE than PSTs of other subjects. This is a difficulty because there is a shortage of science teachers, and I became interested in how I could better support them.

Initial ideas included that science teachers are not very reflective (Malthouse & Roffey-Barentsen, 2014), which might be a difficulty for science PSTs on a programme that adopts a reflective practitioner model. I implemented an intervention designed to support them in being reflective, involving Tripp's (1993) DTC; and AL (Bayley, 2015).

The whole group of 38 science PSTs took part in the intervention, of whom 8 volunteered to participate in the research. Data collected and analysed included reflective journals; critical incident analyses; audio recordings of AL sets; action plans and reviews of action plans; reviews and reports on participants' teaching.

In the remainder of this chapter, I consider what I learned from carrying out the study. I begin by presenting the answers to the RQs. I then reflect on theory, considering strengths and limitations of the study. Since it was carried out for an Ed.D., implications for practice are particularly important. Since policy and practice in ITE are intertwined, I consider them concurrently. I also consider implications for future research, and the contribution of the study. Finally, I include my reflections in light of my professional experiences.

8.2 Answers to the research questions

In this section, I summarise the outcomes of the study from each of the data analysis chapters (Chapters 5 to 7), referring to the relevant RQs. Hence I present this material in three parts – participants' reflective practice; barriers to participants' development; and evaluating the teaching intervention.

8.2.1 Answers to research questions about participants' reflective practice

In Chapter 5, I considered participants' reflectivity, using Zwozdiak-Myers' (2012) nine dimensions of reflective practice as an analytical framework. The related RQ is:

- To what extent are participants reflective?

SQs are:

  - To what extent are participants wed to transmission modes of teaching?
  - To what extent are participants linking theory with their practice?
  - To what extent is participants' reflectivity related to their success in learning to teach?

As shown in the heat map of reflectivity (5.3) there was variation in participant reflectivity, both between participants, and across the dimensions. Based on the heat map, Zoe and Dean might be considered to be the most reflective participants, and Kathryn and Paul the least.

One of the weaknesses was that participants did not systematically evaluate their teaching through classroom research procedures (*Dimension 2*). Although I had suggested a range of classroom data they could collect, and ethical procedures for obtaining consent were in place, participants did not do so.

A relative strength was *Dimension 6 Try out new strategies and ideas*, since there was evidence of participants adopting a range of teaching approaches, including, for example, practical work, and research and presentation tasks. However, they may have switched to lecture mode when faced with topics they found difficult to teach, and those that lacked practical work.

Another relative weakness was that participants did not question their own or one another's assumptions (*Dimension 4 Question your personal theories and beliefs*). Also of interest was that *Dimension 3 Linking theory with practice* was not a strength. This was notable because one of the aims of Tripp's (1993) approach was to overcome the theory-practice divide.

Overall, some participants were more reflective than others, and participants were more reflective in some dimensions than in others.

To what extent are participants wed to transmission modes of teaching?
In answering this SQ, I considered *Dimension 6 Try out new strategies and ideas*, as well as aspects of *7 Maximise the learning of all your pupils* and *8 Enhance the quality of your own teaching*. *Dimension 7* included questioning practices, which might be encompassed within dialogic teaching. In *Dimension 8*, I included development of PCK, which entails a concern for making topics intelligible to pupils.

In addition to adopting a range of teaching strategies, there was evidence of numerous participants using a range of approaches to obtaining feedback. These included developing the use of oral questioning, and using exit tickets and quizzes, for example. There was rather less evidence of discussion of PCK, with Dean being the most specific about strategies for teaching chemical bonding (5.4). Whilst there was certainly evidence of adopting active approaches and being interested in obtaining feedback, it was not clear that participants used questioning diagnostically, or that activities were used to promote discussion of children's ideas, or to create cognitive conflict.

Overall, participants were not necessarily wed to transmission modes of teaching, since they adopted a range of strategies for teaching, and were interested in obtaining feedback from pupils. However, when the AL sets came to an end, in April, there was room for further development in teaching for understanding.

To what extent are participants linking theory with their practice?
In answering this question, I analysed the data for *Dimension 3 Linking theory with practice*. I looked for instances of application of theory – putting concepts and theories which were taught on the PGCE course into practice – and at practical theorising. I used Korthagen and Lagerwerf's (2001) model of *gestalt*, *schematization* and *theory* to analyse participants' practical theorising.

There was little evidence of participants applying theory to practice. The one explicit reference to a named theorist was the use of Bloom's taxonomy to plan questions, which Rachael mentioned in her April AL set (4.3.4).

Analysis of practical theorising suggested that most of participants' thinking was at the level of gestalt or schema. Dean perhaps went closest to articulating a theory when using the fight-or-flight response to explain a pupils' behaviour (Connor's AL set, December). The extent to which participants articulated personal theories of practice was thus limited.

Overall, there was little evidence of participants putting theory into practice or of practical theorising.

To what extent is participants' reflectivity related to their success in learning to teach?

I compared evidence for the dimensions of reflective practice for four participants with known course outcomes (Fig.9, p.125). CM, who withdrew from his course of ITE, nominally owing to his concern about his pupils' progress, appeared at least as reflective as other participants in many dimensions. Whilst both Zoe and Emily attained 'outstanding' grades for their teaching at the end of the programme, the heat map suggested that Zoe was much more reflective than Emily.

Overall, there was no correlation between reflectivity and course outcome.

8.2.2 Answers to research questions about barriers to participants' development

In Chapter 6 *Barriers to participants' development*, I considered participants' progress on the programme, focusing on Furlong and Maynard's (1995) model of development. The related RQs are:

- What are the barriers that science PSTs face during their PGCE?
- How does the development of participants' teaching compare with the stages of development of PSTs in the literature?
    - Why might participants have found it difficult to develop CBM?

What are the barriers that science PSTs face during their PGCE?
I carried out a thematic analysis of teaching issues recounted in reflective journals, critical incident analyses and audio recordings of AL sets (6.2). Across the different data sets, issues most frequently raised were to do with CBM. Some of these concerned ways in which participants themselves needed to develop, such as improving their presence, assertiveness and use of voice. Several participants recounted having difficulty in getting pupils' attention, or in getting talkative classes to be quiet. They raised difficulties in dealing with a range of other situations, which included backchat from pupils, pupils refusing to work, and pupils wandering around the classroom, for example.

Overall, participants' predominant concern was CBM.

How does the development of participants' teaching compare with the stages of development of PSTs in the literature?
I analysed the data using Furlong and Maynard's (1995) model of stages of development of PSTs' teaching (6.3). I observed many of the features of the first three stages that Furlong and Maynard proposed – *Early Idealism*, *Personal Survival* and *Dealing with Difficulties*. There was not much evidence, by April, of *Reaching a Plateau,* or *Moving On.*

In terms of *Early Idealism,* there was some evidence of participants wanting to have warm and friendly relationships with pupils. There was plentiful evidence at the *Personal Survival* stage of participants having difficulties in asserting authority, and in communicating expectations with pupils. They were tested by their pupils, and often experienced strong feelings. In contrast, there was no evidence of participants adopting the class teacher's style. Some participants moved on to the *Dealing with Difficulties* stage. They began to improve their CBM, and gained confidence. They wanted to impress teachers and tutors, and were upset by criticism. They may have focused more on classroom strategies and organisation than on learning, although some participants began to give greater consideration to assessment. In contrast, I did not see participants becoming overly controlling of pupils' behaviour, and nor did they appear to be reticent about differentiation.

Significantly, participants seemed to spend much more time in the *Personal Survival* phase than Furlong and Maynard suggested. In the literature, this phase lasted only a few weeks, but many of my participants appeared to be at this stage throughout their first teaching placement, and perhaps some were still there by April.

Overall, there were many similarities between the trajectories of the participants and the stages proposed by Furlong and Maynard. However, participants were slow to progress through the stages, appearing to spend a long time in the *Personal Survival* phase.

Why might the participants have found it difficult to develop CBM?
I considered participants' data in light of Furlong and Maynard's (1995) suggestion that development of appropriate working relationships with pupils underpins CBM (6.4).

There were several features of participants' working relationships with pupils that were similar to those described in literature, and which may have made it difficult for them to develop their CBM, including:

- There was evidence of some participants wanting to be liked by pupils, which Furlong and Maynard characterise as having idealistic views of the warm and friendly relationships they will be able to have.
- Some participants were also reticent about using rewards, in common with Reupert and Woodcock's (2010) observation of PSTs.
- Some may also have needed support to manage their feelings of anger and frustration.
- Many participants appeared reticent to assert their authority and to apply sanctions, which resonated with two studies that found science PSTs to be non-interventionist (Maskan, 2007; Savran & Çakıroğlu, 2003).
- Participants may have needed support in holding all pupils in positive regard, particularly where they presented with challenging behaviours.

I discuss these observations further in section 8.3.3, where I reflect on theoretical underpinnings of the data analysis.

8.2.3 Answers to the research question about evaluating the teaching intervention

In Chapter 7, I evaluated the teaching intervention, particularly focusing on the elements of reflection, community, action and feedback that were suggested by Aubusson *et al.* (2009). The related RQ is:

- How well did the teaching intervention work to support participants' development?

The parts of the intervention that could have stimulated reflection were keeping reflective journals and completing analyses of critical incidents; and open-ended questioning in AL sets. Completion of journals was patchy, perhaps because PSTs were too busy, and perhaps both journal writing and critical incident analysis suffered from some science PSTs' lack of confidence in writing prose. Given the many conflicting demands on PSTs' limited time on a PGCE programme, I would need to consider carefully how these might be used in the future. Perhaps even greater support and scaffolding for writing is needed, but time for this activity would be at the expense of something else. Oral reflection in AL sets was more successful. As the year progressed, some participants became more appreciative of open-ended questioning in helping them to reflect, and less reliant upon AL sets for obtaining a bank of ideas. There was some evidence that open-ended questioning enabled participants to come up with their own solutions to their teaching issues, as Bayley (2015) suggested.

Aubusson *et* al. (2009) suggested that AL supports questioning of assumptions. Linking with *Dimension 4 Question your personal theories and beliefs*, the teaching intervention did not enable participants to do this, which seemed to be similar to findings of Plauborg (2009). Since PGCE courses explicitly aim to encourage criticality, I would wish to address this issue in future. As a tutor, I found it particularly concerning how frequently participants unquestioningly referred to children's ability when discussing their teaching issues, and I would wish to find ways in which their assumptions about it might be challenged. I note that some ITE courses include more regular opportunities for PSTs to meet in the university than others, e.g. one day per week over a prolonged period. Perhaps assumptions can be challenged through reference to relevant research, together with time for discussion, with tutor intervention.

Working collaboratively had a number of benefits. Participants appreciated the opportunity to share their experiences and, in common with Plauborg (2009), to gather ideas about teaching. There was evidence of them supporting and encouraging one another, which Stark (2006) also found to be a benefit. There was also some evidence of participants challenging one another. For example, in the December AL set, peers asked Kathryn why she had not set any detentions for Year 10, even though their behaviour may have warranted it.

Participants often fed back orally to the AL set, and some completed written reviews of their action plans. One participant, Rachael (April AL set), said that she had found the process of action planning helped in keeping track of her development over time. However, some participants appeared not to take action, particularly around developing CBM. There was also some feedback about participants' development from mentors' reviews and reports on their teaching. However, participants did not systematically collect evidence from school placements, which Penney and Leggett (2005) had also found to be a difficulty.

Overall, completion of reflective journals was patchy, and those that were completed varied considerably in length and reflectivity. The quality of written critical incident analyses was weak, overall. However, participants were positive about AL sets. They appreciated the opportunity to share experiences (even though this was often *Schadenfreude*). They supported and encouraged one another, as well as challenging one another at times. They seemed to gain better understandings of their teaching issues, and to come up with solutions. A significant weakness was that the process did not enable them to question their assumptions. Further weaknesses of the DTC process were that some participants did not implement their action plans, and feedback was limited to participants' oral reports.

8.3 Reflection on theory

In this section, I discuss the theoretical underpinnings of the study. I present this material in three parts which consider previous research about difficulties with science teaching; the teaching intervention; and the data analysis.

8.3.1 Reflection on previous research about difficulties with science teaching

Malthouse and Roffey-Barentsen (2014:179) asked 'Are science teachers immune to reflective practice?', and tended to suggest that they are. My findings are, to some extent, at odds with their suggestion. It would be fair to say that some participants were more reflective than others; and that they were more reflective in some ways than in others; that they reflected better orally than in writing; and that perhaps they became more reflective as the project progressed.

Concern had been expressed that science teachers teach in the way that they were themselves taught – by transmission and rote learning (Loughran, 2007). Much science education literature assumes that children learn science through constructivist teaching approaches, which encourage diagnosis of misconceptions, higher-order questioning and discussion, and enquiry, for example. (See, for example, Yilmaz, 2008.) The evidence suggested that participants used a range of activities, including practical work, making models, ICT, and role-play, for example. Some of these approaches have the potential to be used to promote discussion of children's alternative conceptions. However, there was no evidence as to how participants used them, so they may have been transmissive. Participants also used different strategies for obtaining feedback from pupils. However, by April, participants were still considering how use assessment data to adapt teaching, which would be consistent with teaching for understanding (Brooks, 1999). In April, Rachael was interested in making her questioning more open-ended. However, there was no evidence of participants using diagnostic questions, which might have elicited information about pupils' preconceptions, and could have formed the starting-point for teaching for understanding (Brooks, 1999). Where participants used science practical work or demonstration, it is possible that their approach was more illustrative than to create cognitive conflict (Nussbaum and Novick, 1982) or to allow open-ended enquiry (Brooks, 1999).

Gilbert (2010) suggested that science PSTs might have a greater challenge in learning to teach because they lack subject knowledge, since it is unusual for them to have A Levels in all three sciences. It had been further suggested that science teachers must understand the topic themselves before they can represent it appropriately to children and before they are able to address children's misconceptions (Finlayson *et al.*, 1998; Van Driel *et al.*, 1998). There was some

evidence of participants considering weaknesses in their subject knowledge to be a difficulty. For example, in the autumn reflective journal, Emily expressed concern about her knowledge of chemistry for teaching fractional distillation. There was also some evidence of participants finding some topics to be more difficult to teach – perhaps those that were more abstract and theoretical, which may have lacked practical work. It is possible that, lacking other ideas about how to teach them, they fell back on lecturing.

Overall, perhaps science PSTs do less well in learning to teach because their understanding of science and their methods of teaching need further development to support pupils' learning. I consider how this issue might be addressed in section 8.5.

8.3.2 Reflection on theoretical underpinnings of the teaching intervention

Reflective practitioner models have been the predominant discourse in ITE for a prolonged period of time. The particular model adopted in this research was an amalgamation of Tripp's (1993) DTC and AL (Bayley, 2015; Aubusson *et al.*, 2009).

Both Aubusson *et al.* (2009) and Tripp (1993) acknowledged similarities between their approaches and Argyris and Schön's double-loop learning. Argyris and Schön (1974:6) described double loop learning as a process of examining and modifying our 'theories-in-use' by developing hypotheses and testing them by experience. Tripp (1993:xviii), however, had suggested that his approach was one of 'triple-loop learning'. He included an initial loop in which teachers come to terms with their feelings about teaching issues. I had inferred that coming to terms with feelings might be one function of group discussion, which in this study took place in AL sets.

Participants certainly had opportunities to express their feelings, which happened both in reflective journals and in AL sets. I am uncertain of the extent to which these activities helped them to process their feelings. However the evidence tended to suggest that they appreciated the social support, which Aubusson *et al.* (2009) identified as a central feature of AL.

A weakness in this study was that participants engaged only to a limited extent with the process of systematically evaluating their teaching. So they were not really seen

to be hypothesis-testing, and hence were perhaps only weakly engaged in double-loop learning.

In terms of creating the conditions that Dillon (2010) suggested for science teacher development, the extent to which the DTC and AL encouraged critical reflection could also be seen to be a weakness. Perhaps the majority of participants' reflections were simple reflective practice, since the process encouraged them to focus on their own teaching issues rather than on their system-wide context (Atkinson, 2004).

Tripp (1993) suggested that his approach might help to overcome the theory-practice divide, where he placed an emphasis on practical theorising. Unfortunately participants neither incorporated theoretical underpinnings into their reflections; nor did they appear to develop their own theories, according to Korthagen and Lagerwerf's (2001) model, to any great extent. Participants appeared to be learning to teach by a process of trial and error, and it appeared that one did not need to be particularly reflective to finish the course with an 'outstanding' grade.

Perhaps it is unrealistic to expect PSTs to develop as reflective practitioners. McIntyre (1993), for example, suggested that PSTs have insufficient experience to reflect on, and hence should not be involved in systematic enquiry into their own and others' practices. My findings run counter to this view. Participants who completed reflective journals seemed quite overwhelmed with experiences.

In *8.5 Implications for policy and practice* I consider how we might better support development of science PSTs as reflective practitioners.

8.3.3 Reflection on theoretical underpinnings of the data analysis

Nine dimensions of reflective practice

It was easier to interpret some of the dimensions in ways that could be used in the analysis than it was others. Here I discuss the ones I consider to have been problematic.

I found *Dimension 1 Study their own teaching for personal improvement* quite difficult to pin down. I chose to interpret it in terms of participants' commitment to the study, looking at the extent to which they participated. However, I appreciate that

another person might have done it differently. Given that Zwozdiak-Myers (2012) writes about several cyclical processes which encompass identifying a problem, reflection in both cognitive and emotional terms, and generating solutions, I suggest that dimension 1 is overarching across the other dimensions.

I interpreted *Dimension 3 Link theory with your own practice* slightly differently than Zwozdiak-Myers. In common with Zwozdiak-Myers, I considered theory to include both episteme (theoretical, abstract but systematically produced knowledge about teaching and learning) and phronesis (practical wisdom). However, whilst Zwozdiak-Myers included subject and pedagogical knowledge in *Dimension 3*, I considered these only within *Dimension 8 Enhance the quality of your own teaching*. There is some overlap in Zwozdiak-Myers' definitions of *Dimensions 3* and *8*, since she includes pedagogic expertise in both. However, perhaps because she writes for a general audience rather than a particular subject discipline, in *Dimension 8* she considers only generic ideas about teaching and learning. It was a conscious decision on my part to consider PCK in *Dimension 8*, since I consider high quality teaching in science to be subject-specific. However, this begs the question as to whether *Dimensions 3* and *8* can be considered to be distinct.

Stages of development of PSTs' teaching

Furlong and Maynard (1995) propose that PSTs progress from having idealistic views, through a period of survival, to attaining basic control, to a stage at which they can begin to consider issues of teaching and learning.

My findings are broadly in line with the suggestion that PSTs go through a phase in which they have difficulty with classroom control; and there was evidence that they felt vulnerable during this period. As time progressed there was evidence of beginning to achieve basic competence in CBM and moving on to begin to give greater consideration to pupils' learning. However, my findings were somewhat at odds with what had been suggested by Fuller and Brown (1975, cited by Furlong and Maynard (1995:76)), because it appeared to take participants much longer to progress through the initial phases of struggle.

Furlong and Maynard had posited that being able to manage behaviour rested upon developing appropriate working relationships with pupils, and to some extent they

characterise this as establishing, or asserting, authority. They go so far as to say that 'It was through the process of asserting power… that student teachers began to discover... 'me-as-teacher'' (Furlong and Maynard, 1995:109). They suggest that in order to achieve appropriate relationships PSTs need (at first) to set aside their ideals about the warm and friendly relationships with pupils that they would like to have. Although, I suggest that this is the trajectory we saw for Connor, my question is 'What if they don't need to?'

For me, Furlong and Maynard's idea of achieving appropriate working relationships with pupils is somewhat bound up with ideas of power and control. Bromfield (2006:189) associates such approaches with behaviourism, and instead advocates more humanistic ones, which may be a better long-term solution. Other studies suggest that science PSTs may be non-interventionist – i.e. not wishing to be controlling (Maskan, 2007; Savran & Çakıroğlu, 2003). Since participants seemed reluctant to assert authority, it is possible that they, too, were non-interventionist in their attitudes. And, what if those attitudes are hard to change? Perhaps if more humanistic approaches are available PSTs do not need to distance themselves from the humanistic relationships they would like to have, even in the short term. Perhaps we should seek to work with them to develop more humanistic classroom management strategies from the beginning.

Coupled with their many references to 'fun' and their reticence about giving rewards, I thought perhaps my participants wished to appeal to pupils' intrinsic motivation (Brophy, 2013). Furlong and Maynard viewed thinking about motivating pupils as a way of reconciling wishing to have humanistic relationships with the need to assert power. Again, what if this problem is not best thought about in terms of asserting power? Brophy suggests that teachers might instead focus on pupils' motivation to learn.

8.4 Strengths and limitations of the study

In this sub-section I consider the strengths and limitations of the study. First, I consider the strengths and limitations of the data. Then, I consider strengths and limitations of the processes involved in implementing the teaching intervention, which affected data collection. Finally, I reflect on my position as an insider, in the sense that I was course tutor as well as researcher.

8.4.1 Strengths and limitations of the research design

A major strength of the study was the richness of the data collected. These included reflective journals, analyses of critical incidents, audio recordings of AL sets and action plans; as well as normal course documents, such as application forms and mentors' reports on PSTs' teaching. The richness of data tends to support our understanding of the process of becoming a science teacher.

To a large extent, the study relied upon participants telling their own stories, attempting to understand science PSTs' development from their point of view. In comparison with other methods, such as questionnaires or structured interviews, the benefit of thematic analysis of participants' accounts is that it does not impose constructs derived from earlier research, or the researchers' interests (Cohen *et al.*, 2011). This process may allow one to gain unique insights. A possible weakness in applying the nine dimensions of reflective practice after data collection was that this entailed leaving out *Dimension 9 Continue to improve your own teaching*. Perhaps it would have been better to carry out a longitudinal study to enable this dimension to be included.

Thomas (2015) states that case studies must include triangulation of data. Triangulation may support construct validity, since it increases the likelihood that the categories used are a genuine reflection of participants' experiences (Cohen *et al.*, 2011). I suggest that this study has achieved satisfactory standards of triangulation insofar as:

- There are multiple types of data collected from participants, which tend to tell similar stories
- My views as a course tutor have been included, particularly in the evaluative element of the case study (Ch.7)
- Mentors' views are present through their completion of reviews and reports of the PSTs' teaching, which were written independently in school placements.

However, particularly when writing about CM's lack of success on the programme, I would have liked to talk to the Professional Coordinating Mentor (PCM) of the

second placement school to find out their view as to why he withdrew. Was CM unsuitable for teaching? Could he have been a mathematics teacher, rather than a physics (with mathematics) teacher with more success? In a course that relies strongly on the partnership between schools and the university, perhaps it was an omission not to have collected any data from PCMs.

Additionally, I might have added to triangulation of the data through other course material that was normally available to me as a tutor. I was personal tutor for six of the eight participants, which means that I carried out lesson observations in their placement schools in November-December. Perhaps my lesson observations notes could have been used to triangulate PSTs' reports of their teaching issues, but I did not consider it at the time. That said, I often do not see pupils behaving badly, perhaps because they behave better than normal when a visitor is obviously taking notes. Anecdotally, PSTs tell me that I have an effect as an observer, which may have made lesson observation data less than representative. I am also not certain how much a one-off observation can contribute, since it may not be indicative of PSTs' teaching as a whole.

I could also have strengthened the evaluative part of the case study by collecting further data. I could have collected data more explicitly about participants' views of the AL sets; as well as about what they thought about the processes of writing reflective journals and critical incident analyses. As it stands, that aspect of the study relies on my own interpretation as tutor and researcher.

To return to the question of construct validity, Yin (2014:45) suggests two other strategies in addition to triangulation, which are establishing the 'chain of evidence' and having 'key informants review [the] draft case study report'. Throughout the thesis, I have attempted to establish the chain of evidence by making clear where particular pieces of evidence can be found in the data. A database of the written material may be inspected by readers of this thesis upon request. Yin (2014) further suggests that the database increases reliability in case study research. However, a limitation of the study is that I have not been able to ask the participants to review material I have written about them, given the difficulty in contacting them now that several years have elapsed since data collection. That said, I hope that I have been

able transparently to communicate the method through which my characterisation of the participants has taken place.

Another element suggested by Yin (2014) for establishing the reliability of a case study is the extent to which another person would derive the same results. In terms of minimising bias in the data analysis I might have adopted a process of having a number of researchers repeat it. This would have enabled me to establish intercoder reliability (Lombard *et al.*, 2010). That said, my study has been shared throughout with critical readers (in the form of my supervisors, research group discussions and conference presentations (Gourlay, 2019)), which may have addressed this limitation.

In terms of achieving external validity, Flyvberg (2006) suggests that it is a misconception that case studies cannot produce generalisable outcomes. Whilst they are not generalisable in the same way as research in the natural sciences, which rely on induction, case studies may still be said to be generalisable. In case study, the extent to which outcomes are generalisable depends on abduction on behalf of the reader (Thomas, 2015). What is the likelihood, given the richness of the data, and the way in which the story of participants' progress has been communicated in the thesis, and one's own professional knowledge and experience, that similar outcomes would be observed with different science PSTs on this course, and with science PSTs on other similar courses in England? My own professional experience, in several different universities, and across several different modes of ITE, suggests that the findings are likely to be more widely applicable than just to the participants concerned. The thickness of description in the thesis may persuade readers that the findings of the case study are transferable to other similar situations (Polit & Beck, 2010). However, conclusions derived in this way are necessarily tentative (Thomas, 2015).

8.4.2 Strengths and limitations of the implementation

The intervention was somewhat additional to, rather than integrated within, the PGCE course, and this led to being unable to maintain the same personnel in AL sets across the study. Stability in the groups would have been preferable in order to establish greater trust (Hoban *et al.*, 1997). Earlier studies also suggested carrying out AL sets at intervals of 4-6 weeks to strengthen the sense of community (Stark,

2006; Hoban *et al.*, 1997). However the course calendar did not support these intervals.

This raises a question about the timing and frequency of AL sets in the PGCE calendar. The timing of the January/February session was not great because one school placement had ended, so participants' teaching issues were sometimes no longer relevant. Participants were unable to go back and change anything as a result discussions that concerned school-specific pupils and situations.

Another limitation was introduced because I changed jobs part-way through the academic year. Had I still been a tutor, perhaps further interventions and AL sets could have taken place beyond April. This might have supported collecting further data about Connor, Dean and Kathryn, and may have given a more rounded view. For example, I have suggested that by April participants tended to value reflection more. Perhaps this is because those who valued reflection more were more inclined to participate. It would also have strengthened evidence about the trajectory PSTs take. Emily would have been particularly interesting to follow into the second placement. Whilst we know the final outcome was 'outstanding', did she struggle with CBM at the start of placement B as others had done previously?

Mentors might also have been more closely involved in implementation of the project. For example, communication of the action plan rested with the participant, rather than between tutor and mentor. Perhaps greater action would have been taken by some participants if mentors had been more aware of their aims.

Overall, however, I am confident that AL was better implemented than a pilot of the process in the previous academic year, since the participants completed several cycles.

8.4.3 Reflection on my position as an insider

Being course tutor probably added to the quality of the intervention as well as posing some challenges of a sensitive nature. Having an established working relationship with participants may have helped to secure buy-in. The response to seminars about reflection and AL was probably better than if I had been an unknown researcher leading occasional sessions. On the other hand, participants may have felt

constrained by the fact that they were being more closely observed than other PSTs on the course, and that their course grade was possibly more at risk.

I was personal tutor for some participants which gave me greater knowledge of the participant than I would have had as an outsider. Arguably, I had greater knowledge of all the participants than an external researcher because I was regularly involved in teaching them all in science education seminars. On the one hand, this may have helped me to interpret correctly what they said, or wrote, about their teaching experiences. On the other hand, this may have been a limitation because my perceptions of events may have been coloured by my expectations. Perhaps knowing in advance that physics/science PSTs do less well on their courses than others becomes a self-fulfilling prophecy.

My insider knowledge of the course may also have introduced some bias. Prior to the project, I would have had preferences and criticisms of the course, based on previous experiences of working for a long period of time in schools, and working across several different modes of ITE and institution. We may all suffer from confirmation bias (Cohen *et al.*, 2011). To the extent that data were analysed systematically, using thematic analysis, I hope that I have avoided it.

8.5 Implications for policy and practice

In this section, I consider some of the implications for the course of ITE, and for policy. I cover what I perceive to be the main issues, which are:

- improving the linking between theory and practice
- adapting the course to take into account science PSTs' progression.

Improving the linking of theory and practice

The data suggested that participants did not make a great deal of reference to material taught in the university; and where Rachael referred to course material about questioning, her interest arose some months after the material was taught. Perhaps Korthagen *et al.* (2001) are right to adopt a more inductive approach, developing from PSTs' observations and experiences. If we were to do this, the content of a course of science teacher preparation might be quite different than the one in the study. In Appendix AA, I suggest a list of topics to be covered, broadly in order of frequency in the data.

In an ideal world, I would like to retain reflective journals, as well as further developing PSTs' writing of critical incidents. However, in the context that schools and ITE courses are asked to reduce workload, courses using reflective journals may need to consider how PSTs' overall workload could be reduced in order to facilitate a higher completion rate, as well as high quality. Completion of journals would need to be instead of something else. At the time, on the course concerned, one possibility would be to reduce PSTs' teaching loads. Owing to the weakness in some of the participants' writing, I am not certain that further developing written critical incidents is realistic in the context that there is not a great deal of time in university sessions (12 weeks), and that there are many competing topics to teach in the time available. However, participants were positive about AL sets, so I would like to retain them.

It may be better to embed AL into the course, helping to ensure that PSTs take part. More frequent AL sets, with stability in the groups, might support development of a learning community (Stark, 2006; Hoban *et al.*, 1997). At the action planning stage, I suggest introducing a period of time for PSTs to carry out further research about how to overcome their teaching issue, including:

- Library searches for research that might be relevant to their teaching issue
- Consulting the course tutor
- Referring to books or websites about teaching for further professional advice
- Referring to published (or online) materials for teaching, e.g. to research different teaching strategies to meet particular pupil needs or to teach particular science concepts
- Further consulting other PSTs

Many of these suggestions would draw upon my professional expertise, and thus may be more supportive of PSTs' development – providing the input of new ideas and theories that Bell and Gilbert (1996) recommended. Perhaps introducing theoretical ideas at the point when PSTs need them might help to overcome their difficulty with putting theory into practice. Additional tutor input might also challenge PSTs' assumptions.

Additionally, this process might support PSTs in systematically evaluating their own teaching (*Dimension 2*). Teacher educators may find it concerning that participants

did not systematically evaluate their teaching. It is possible that ITE in England placed a greater emphasis on enquiry in the past. I think there are important questions that PSTs should be encouraged to ask about what counts as evidence, and about the strength of evidence. Arguably, if we are serious about developing high quality teaching then systematic evaluation is essential. PSTs and tutors could work together on planning methods of assessing the success of the implementation of their action plans – going beyond their own oral reports of their progress, and the assessments of mentors.

In policy terms, the DfE recommends a list of core content for ITE (DfE, 2016). Whilst this material is not statutory, my professional experience has been that course leaders have tended to cover it owing to concern about Ofsted. Coverage may not be compatible with the more learner-centred approach I suggest. Policy-makers may need to consider what is achievable in a 9-month course, and what might be deferred into additional professional development or teacher education in the first few years of teaching.

Adapting the course to take into account science PSTs' progression

Whilst it was not entirely unexpected that PSTs would experience CBM issues, the extent to which it dominated was significant – particularly during the first placement. I suggest the need for the course to consider how it might further support the development of science PSTs' CBM strategies. To place greater emphasis on development of CBM may require significant change to the course. More time spent on learning about CBM will necessarily entail less time spent on something else.

If it is generally the case that science PSTs spend a large part of the course getting to grips with CBM, and if, as Furlong and Maynard (1995) suggest, they then reach a plateau, there are implications. Perhaps science PSTs need tutor intervention in the April-June phase, because this is the point at which they are ready to consider pupils' learning.

On all the university-schools partnership PGCE courses on which I have worked there has been comparatively little contact between tutors and PSTs in the latter stages of the course – perhaps limited to a tutorial and a school visit in the April-June period. In this context, it is hard to see how science tutors could move their

students on. Two of those courses have a master's level assignment which considers relevant material from the field of science education research about how children learn in science. Perhaps placing this assignment later in the year, to coincide with a time when science PSTs may be more ready to engage with the material (since they have moved on from the survival phase), would help to address this concern.

The timing of the transfer from placement A to placement B is also something that ITE courses structured in this way may wish to reconsider. The data suggested that science PSTs focused predominantly on CBM throughout the first placement. The imminent end of the first placement also seemed to adversely affect motivation about tackling teaching issues (7.4). Perhaps the first placement could be longer, giving PSTs opportunity to develop basic competence in CBM, and then to prioritise developing PCK.

One difficulty with this suggestion is that Emily did not experience any CBM issues in first placement. Perhaps course leaders should consider whether all PSTs should complete their first placement in schools where they have opportunity to work on this aspect of their practice. Another possibility is that perhaps some of the other placements were unsuitable because PSTs were not adequately supported (by tutors, mentors or class teachers, and perhaps school leaders) to overcome the challenge.

Participants were often conscious of their place in the school not being 'a real teacher', in line with Furlong and Maynard's (1995:78) findings. This may have been a factor that held them back from taking ownership of CBM. School partners may wish to think about how PSTs can be treated as far as possible like a teacher. Whilst being supportive of a university-schools partnership model in which PSTs are supernumerary, perhaps policymakers could consider making all PSTs paid employees, to create a greater sense of belonging. In common with Furlong and Maynard's PSTs, Paul thought it would have been helpful to observe teachers establishing themselves with classes at the beginning of the year (January AL set) – a development that might be possible if PSTs were more firmly attached to a particular school.

To return to developing science teaching and learning, science teachers are unique in being asked to teach three different subject specialisms to GCSE level, when their

highest qualification in one or more of these subjects may be GCSE (Gilbert, 2010). Concern about teaching outside specialism came up for several PSTs. Coupled with that, there were some topics that PSTs found difficult to teach, perhaps because they lacked knowledge of how they might teach it. Some PSTs also noted issues related to lack of subject-specialist teachers in their school placements, so it is not clear to me that this material can necessarily be learned in school. Whilst the course concerned could probably be modified somewhat to create space for more work about teaching science, policymakers might consider funding a longer course of ITE.

Policy-makers might consider how physics PSTs could be further supported, going beyond generous bursaries. Perhaps more intensive support, such as counselling, is needed to improve their assertiveness and resilience.

8.6 Implications for future research

Over the course of writing up the project, I spent much time considering CM's withdrawal from the course. Given the chronic shortage of physics teachers, I remain interested in what we might do to support them. Professional experience suggests that some physics PSTs are much more successful than others. It would be interesting to carry out a further project looking at the factors affecting their progress, comparing successful cases with unsuccessful cases. I wonder whether some institutions have better outcomes for physics PSTs than others. If so, what represents good practice in physics teacher preparation?

Since I suggest that one of the main implications for practice is developing CBM, it would be helpful for research to consider:

- To what extent do PSTs across England struggle to develop CBM? (Is this unique to science PSTs, or just my participants?)
- What are current practices in developing CBM in ITE courses? To what extent are they successful?
- What does research/professional expertise suggest about developing CBM further?

I would then suggest a pilot of an intervention, with an accompanying evaluation. The project raised the possibility of a tension between humanistic and behaviourist approaches, which may need to be resolved.

I have suggested that science PSTs found written critical incident analysis challenging, and that I would need to consider how to implement it more successfully if I were to use it again. I note that I did not seek participants' views. A future research project could seek the views of participants as to whether they found Tripp's strategies helpful in reflecting on their teaching issues, whether they think it should be retained in the programme, and how it might be used more successfully. If carrying out a future intervention with teachers, I would suggest looking more systematically at their views of its helpfulness, e.g. through questionnaires, focus groups or interviews. For a more 360-degree view, it would also be helpful to collect data from mentors, PCMs, and other tutors.

It would be interesting to continue the intervention into the NQT year, and beyond, and to research its impact on science teacher development over this extended period. I hypothesise that the peer support reported during this project would be beneficial for successful completion of the NQT year, and perhaps for retention in the teaching profession. A future project could investigate the impact of such an intervention. Would it be any more successful in developing reflective practice, and helping PSTs to make links between theory and practice?

I have suggested that a longer period might be needed in order for science PSTs to begin to consider science learning. I hypothesise that this is something that PSTs would do once they have got to grips with CBM. Hence a longer research project may be able to investigate development of science teachers' science teaching, evaluating the extent to which they engage in thinking critically about issues of effective teaching and learning in science.

8.7 Contribution to the field of science teacher education

In addition to providing some directions for future research, my study has made several contributions to the literature on science PSTs' development.

Science PSTs were given a voice and their development needs were revealed

Loughran (2007:1045) suggested that we needed to understand 'what student teachers are confronted by', and Clandinin (1992) suggested that science PSTs had not really been listened to. By focusing on participants' reflective journals and audio recordings of AL sets, I have given science PSTs a voice. More recently, Davis *et al.*

(2006) suggested that we need to know more about new science teachers' needs. This study has revealed what some of those needs might be.

Science PSTs made slow progress in developing CBM

Participants generally struggled to develop CBM, and I suggest that their difficulties are a major concern. This lends weight to the suggestion that behaviour is a problem in schools in England (Rudgard, 2017; DfE, 2016a; DfE, 2017), and adds to it by highlighting that it may be a particular difficulty for science PSTs.

Fuller and Brown (1975, cited by Furlong and Maynard (1995:76)) had suggested that the *Personal Survival* phase 'may last for one or two weeks', and Furlong and Maynard (1995:94) themselves referred to PSTs moving on to think about children's learning 'after the first few weeks of survival and confusion, having now attained basic control, competence and confidence in teaching skills and strategies'. My data contradict the suggestion that CBM is developed over the course of a few weeks. This process may take significantly longer for secondary science PSTs, and consequently we may wish to consider how we might better support its development in ITE.

Science PSTs are not necessarily immune to reflective practice

It was suggested that science PSTs are not very reflective (Malthouse & Roffey-Barentsen, 2014), and that this might be related to positivism. My study makes a contribution by adding nuance to this argument, suggesting that science PSTs are more reflective in some ways than in others.

Science teachers have traditionally been perceived to be wed to transmission modes of teaching. However, participants were seen to be relatively reflective in *Dimension 6 Try out new strategies and ideas*, and became increasingly interested in obtaining feedback from pupils about their learning. Whilst there was still room for development in participants' teaching for understanding by April (perhaps because they had spent a long time getting to grips with CBM), overall I think the evidence of them adopting active teaching approaches is sufficient to suggest that they did not necessarily conform to 'science teaching as telling' (Loughran, 2007:1043). If transmissive modes of teaching are linked to positivism, as has sometimes been

suggested (Tsai, 2007), then I tentatively suggest that the research participants were not locked in positivism, but this question merits further investigation.

Although one of the intentions of the intervention was to bridge the theory-practice divide, participants did not use theory to any great extent. The data suggested that they were not very reflective in *Dimension 3 Linking theory with practice*, with reference to only a single named theorist – Bloom. This finding may give teacher educators pause. It raises questions about how we can better introduce PSTs to theory, and support them in developing the skills to use it in their teaching practice.

The use of AL was innovative, and beneficial

Whilst AL had been used extensively with qualified teachers in Australia, researching its use in a PGCE course in England was innovative. Whilst acknowledging the limitations mentioned above (8.4.2), it did appear to have benefits, particularly in terms of the peer support it provided. Overall, I suggest that through the study I have demonstrated the potential for AL to support PSTs during their ITE courses in England.

8.8 Personal reflection

Overall, I found the outcomes a bit depressing. ITE tutors work very hard, and it was rather galling to find that it appeared that science PSTs may not be learning much from the university programme. I would now approach ITE for secondary science teachers differently, given the opportunity.

I was very much affected by the experience of working with CM. My own view is that CM demonstrated many of the characteristics needed to become a teacher, and it is a shame that he withdrew from the programme. We need more physics teachers. In this context, another consideration for ITE courses may be how to help PSTs to develop greater resilience when they face challenges.

In a conversation about his experience, CM referred to attempting the PGCE as like Kobayashi Maru – a reference to Star Trek (for example Meyer *et al.,* 1982; Abrams, 2009). Captain Kirk is faced with a simulation of an event which is insurmountable – a lose-lose situation. Kirk only manages to win by cheating – he re-programmes the simulator so that it is possible to win. If this is how good people like CM experience

ITE, perhaps we need to re-programme ITE to enable a higher proportion of the people who wish to be physics teachers to succeed.

Schön (1987:37) defined practicum as:

> A setting designed for the task of learning a practice. In a context that approximates a practice world, students learn by doing, although their doing usually falls short of real-world work. They learn by undertaking projects that simulate and simplify practice; or they take on real-world projects under close supervision. The practicum is a virtual world, relatively free of the pressures, distractions, and risks of the real one, to which, nevertheless, it refers.

As it stands at the moment, I would suggest that teaching practice often fails to provide science PSTs with a suitable practicum, in that they are exposed too rapidly to the whole gamut of challenges of being a teacher. They are not free of its 'pressures, distractions, and risks' (*ibid*) to any great extent, whilst they take their first steps in teaching.

I was well aware that school placements are challenging prior to beginning the project. In my research proposal for this study, for example, I wrote:

> My experience of working on the traditional PGCE courses at Red University and Green University suggests that one of their main strengths is that beginning teachers have regular opportunities to come out of the crucible that is the school placement, to share their ideas and experiences with one another (Gourlay, 2015).

A crucible is an environment at very high temperature, in which materials undergo physical or chemical changes, becoming a different state, or a different substance. Whilst not doubting the need for PSTs to be transformed during their course of ITE, I wonder whether the particular type of transformation required is best carried out at a such a high temperature, so to speak. Would it not be better if an introduction to teaching was more measured?

If anything, completion of the project moved me beyond the crucible analogy to consider the nature of PSTs' experiences over the course of the whole year. One of my students in a more recent PGCE cohort suggested it was like Frodo's ring quest in *The Lord of the Rings* (Tolkein, 1968). Obtaining qualified teacher status is analogous to carrying the one ring to Mordor and throwing it into Mount Doom. I consider this a worse situation to be in than the crucible. Being closer to participants'

lived experiences through reading their written data, and listening intently to the audio recordings of AL sets, revealed to a greater extent the nature and severity of the many challenges they face.

Conceiving of the course in this way led me to do a brief literature search on the terms such as 'hero quest becoming teacher training'. It transpired that Goldstein (2005:21) used an intervention with PSTs in Texas, in which she used the concept of the hero's journey in *Star Wars* as a metaphor in an intervention to support completion of an ITE course:

> The hero's journey metaphor offered these preservice teachers guidance and encouragement, allowed them to tap into hidden strengths within themselves, helped put their frustrations and setbacks into perspective, and provided them with membership in a community of support and encouragement.

To continue with the *Star Wars* theme, perhaps this approach offers us *A New Hope* (Lucas, 1977).

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Appendices

Appendix A: Summary of the Teachers' Standards

Department for Education

Teachers' Standards

PREAMBLE

Teachers make the education of their pupils their first concern, and are accountable for achieving the highest possible standards in work and conduct. Teachers act with honesty and integrity; have strong subject knowledge, keep their knowledge and skills as teachers up-to-date and are self-critical; forge positive professional relationships; and work with parents in the best interests of their pupils.

PART ONE: TEACHING

A teacher must:

1 Set high expectations which inspire, motivate and challenge pupils

- establish a safe and stimulating environment for pupils, rooted in mutual respect
- set goals that stretch and challenge pupils of all backgrounds, abilities and dispositions
- demonstrate consistently the positive attitudes, values and behaviour which are expected of pupils.

2 Promote good progress and outcomes by pupils

- be accountable for pupils' attainment, progress and outcomes
- be aware of pupils' capabilities and their prior knowledge, and plan teaching to build on these
- guide pupils to reflect on the progress they have made and their emerging needs
- demonstrate knowledge and understanding of how pupils learn and how this impacts on teaching
- encourage pupils to take a responsible and conscientious attitude to their own work and study.

3 Demonstrate good subject and curriculum knowledge

- have a secure knowledge of the relevant subject(s) and curriculum areas, foster and maintain pupils' interest in the subject, and address misunderstandings
- demonstrate a critical understanding of developments in the subject and curriculum areas, and promote the value of scholarship
- demonstrate an understanding of and take responsibility for promoting high standards of literacy, articulacy and the correct use of standard English, whatever the teacher's specialist subject
- if teaching early reading, demonstrate a clear understanding of systematic synthetic phonics
- if teaching early mathematics, demonstrate a clear understanding of appropriate teaching strategies.

4 Plan and teach well structured lessons

- impart knowledge and develop understanding through effective use of lesson time
- promote a love of learning and children's intellectual curiosity
- set homework and plan other out-of-class activities to consolidate and extend the knowledge and understanding pupils have acquired
- reflect systematically on the effectiveness of lessons and approaches to teaching
- contribute to the design and provision of an engaging curriculum within the relevant subject area(s).

5 Adapt teaching to respond to the strengths and needs of all pupils

- know when and how to differentiate appropriately, using approaches which enable pupils to be taught effectively
- have a secure understanding of how a range of factors can inhibit pupils' ability to learn, and how best to overcome these
- demonstrate an awareness of the physical, social and intellectual development of children, and know how to adapt teaching to support pupils' education at different stages of development
- have a clear understanding of the needs of all pupils, including those with special educational needs; those of high ability; those with English as an additional language; those with disabilities; and be able to use and evaluate distinctive teaching approaches to engage and support them.

6 Make accurate and productive use of assessment

- know and understand how to assess the relevant subject and curriculum areas, including statutory assessment requirements
- make use of formative and summative assessment to secure pupils' progress
- use relevant data to monitor progress, set targets, and plan subsequent lessons
- give pupils regular feedback, both orally and through accurate marking, and encourage pupils to respond to the feedback.

7 Manage behaviour effectively to ensure a good and safe learning environment

- have clear rules and routines for behaviour in classrooms, and take responsibility for promoting good and courteous behaviour both in classrooms and around the school, in accordance with the school's behaviour policy
- have high expectations of behaviour, and establish a framework for discipline with a range of strategies, using praise, sanctions and rewards consistently and fairly
- manage classes effectively, using approaches which are appropriate to pupils' needs in order to involve and motivate them
- maintain good relationships with pupils, exercise appropriate authority, and act decisively when necessary.

8 Fulfil wider professional responsibilities

- make a positive contribution to the wider life and ethos of the school
- develop effective professional relationships with colleagues, knowing how and when to draw on advice and specialist support
- deploy support staff effectively
- take responsibility for improving teaching through appropriate professional development, responding to advice and feedback from colleagues
- communicate effectively with parents with regard to pupils' achievements and well-being.

PART TWO: PERSONAL AND PROFESSIONAL CONDUCT

A teacher is expected to demonstrate consistently high standards of personal and professional conduct. The following statements define the behaviour and attitudes which set the required standard for conduct throughout a teacher's career.

- Teachers uphold public trust in the profession and maintain high standards of ethics and behaviour, within and outside school, by:
  - treating pupils with dignity, building relationships rooted in mutual respect, and at all times observing proper boundaries appropriate to a teacher's professional position
  - having regard for the need to safeguard pupils' well-being, in accordance with statutory provisions
  - showing tolerance of and respect for the rights of others
  - not undermining fundamental British values, including democracy, the rule of law, individual liberty and mutual respect, and tolerance of those with different faiths and beliefs
  - ensuring that personal beliefs are not expressed in ways which exploit pupils' vulnerability or might lead them to break the law.
- Teachers must have proper and professional regard for the ethos, policies and practices of the school in which they teach, and maintain high standards in their own attendance and punctuality.
- Teachers must have an understanding of, and always act within, the statutory frameworks which set out their professional duties and responsibilities.

The Teachers' Standards can be found on the GOV.UK website: https://www.gov.uk/government/publications/teachers-standards

DfE (2011)

Appendix B: End of course grades for different PGCE subjects

Grade	English (n=51)	History (n=46)	Modern Foreign Languages (n=51)	Physical Education (n=49)	Sciences (n=86)	Physics and Physics with Mathematics (n=15)
Outstanding	60.8%	56.5%	60.8%	53.1%	44.2%	20.0%
Good	33.3%	43.5%	39.2%	46.9%	46.5%	66.7%
Requiring improvement	5.9%	0.0%	0.0%	0.0%	9.3%	13.3%

Note that the group labelled ‘physics and physics with mathematics’ is a subset of the ‘sciences’ group. In this period there was only one Physics with mathematics PST, and they predominantly followed the same programme as the other scientists.

Appendix C: Tripp's kinds of judgment and analysis

Kind of judgement	*Kinds of analysis*		
	Information required	*Questions asked*	*People involved*
Practical	Procedural	What should I do? How? When? Where?	For and/or with whom?
Diagnostic	Descriptive	What happened?	Who was involved?
	Causal	What made it happen?	Who acted?
	Effectual	What does it do?	For whom?
	Affectual	What does it feel like?	For whom?
	Semantic	What does it mean?	To whom?
	Explanatory	Why did (does) it occur?	With whom?
Reflective	Personal Evaluative Justificatory	Do I like it? Is it a good thing? Why?	Do others like it? For whom?
Critical	Classificatory	What is it an example of?	Whose classification?
	Social	Is it just?	For whom?

Tripp (1993:27)

Appendix D: Tripp's Thinking Strategies

Approach	Sub-approach	Description
Thinking strategies	Positive, negative, interesting	Clarifying what we like or dislike.
	Alternatives	What else might have happened? How could we have made that happen?
	Other points of view	Look at the incident from someone else's point of view, e.g. a student
	Parts and qualities	'Because teaching is a social practice, we must examine our attitudes, values and judgments and work on those too.' (p 45)
	Reversal	Look at it from the opposite point of view
	Omissions	What did we leave out?
The why? challenge		Socratic questioning
Dilemma identification		'...the schooling process contains a number of major contradictions' (p 49) Identify dilemma and work out how best to resolve it.
Personal theory analysis		On what assumptions are our professional judgments based?

Tripp (1993)

Appendix E: Protocol for an AL set

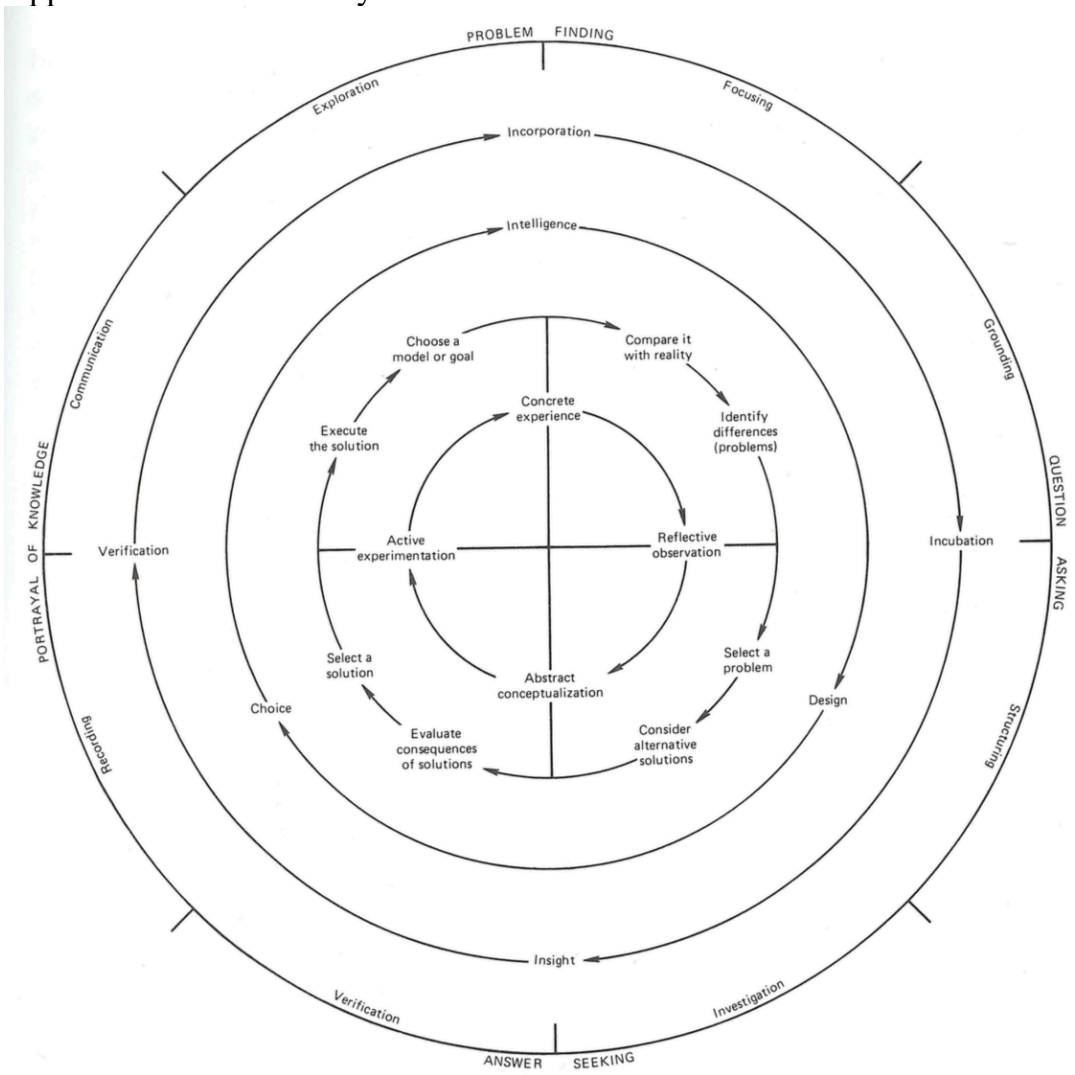
1. Think of an issue/challenge which you have/will face related to beginning block placement.
2. One by one outline your challenge/issue to the rest of the group. The group will then choose one person's issue that they would like to explore further. This person becomes the Presenter. *(5 minutes)*
3. The group then decides upon a facilitator who will control the timing and running of the process and help agree a contract between the group. (Appendix E)
4. The process begins by the presenter, presenting their issue in greater depth. *(5 minutes)*
5. Next, the facilitator will allow the rest of the group to begin one by one asking open questions to encourage the presenter to explore and reflect upon their chosen issue further. (Appendix F) *(10 minutes)*
6. The facilitator ends the questioning and asks the presenter to reflect on the conclusions they have made and 'next steps'/actions that they plan to take to move on with the issue in light of the process. (*5 minutes*)
7. The whole group will then review the process. What did we do? How did we do? What did we learn? (*5 minutes*)

Appendix F: Open-ended questions for AL sets

What result do you want?	What is your biggest difficulty of problem?	How do you feel about this situation?
What could you do differently?	Why can't you do it?	What judgments are you making about the situation/this person?
What learning are you taking from this session?	What are you trying to achieve?	What can you do about it?
What would make the situation better?	How does the situation affect you?	How could you solve this problem?
What's the most extreme measure you could take?	What's the best possible outcome?	What's the worst thing that might happen?
What options are open to you now?	What could you start to do differently?	When will you start?
Who could help?	How important is this to you?	What action are you going to take?

Bayley (2015)

Appendix G: The Kolb Cycle



Kolb (1984:33)

Appendix H: Summary of Professional Development programme

Date/Time	Topic/ Venue
12/9	Welcome talks Introduction to: Student Support Service; Students' Union; Library Service; Norwich Nightline
14/9	Introduction to the Teachers' Standards Preparing pupils for learning Teen Brains Introducing the 11-19 Education Agenda Accessing Library resources – optional session
21/9	Ideas about learning Safeguarding D of E briefing – optional session
28/9	Preparing for assignments Assessment for Learning Differentiation/using plenaries for learning
5/10	EAL teaching strategies Inclusion/SEN-D Understanding behaviour
17/10	Equal Opportunities and Diversity/ Managing Pupil Behaviour E-Safety Language and Learning
19/10	Behaviour management panel Teacher Identity and Professionalism
12/12	Job application and interviews
25/1	KS2-3 transition process Addressing bullying - focus on homophobia Working with parents/carers/other professionals Identifying and supporting young carers
1/2	PSHE and the changing role of the form tutor Sex and Relationships Education Global Citizenship/SMSC Teaching Fair (optional)
2/2	Effective intervention (Pupil Premium focus) Diversity and community cohesion Strategies for EAL + working with deaf children

8/2	Understanding school data Introducing the School-based Project Working in a Sixth form College
19/4	The 'Prevent' strategy
5/6	Educational Visits Progression in Practice NQT Induction/ Continuing Professional Development
22/6	Entering the Teaching Profession The NQT year and beyond

Appendix I: Summary of science curriculum programme (autumn term)

Date	Main Session	Research focus
Monday, September 12 (am)	Introduction & Administration	
Monday, September 12 (pm)	Introduction of microteaching What makes a good presentation? Lesson planning 1: Objectives and outcomes	Constructivism CLIS
Tuesday, September 13 (am)	AfL1: Questioning	The Black Box Dialogic Teaching
Tuesday, September 13 (pm)	Practical work 1: Managing practical work/safety	
Thursday, September 15 (am)	Lesson planning 2: Sequencing: SoW>Medium term plan>lesson plan	Constructivism CLIS
Thursday, September 15 (pm)	Microteaching presentations	
Friday, September 16 (am)	Tutorials/prep for BCP sessions	
Friday, September 16 (pm)	Tutorials/prep for BCP sessions	
Thursday, September 22 (am)	Learning 1: Learning theories/writing at M-level	Constructivism CLIS
Thursday, September 22 (pm)	Learning 2: CASE	Cognitive Acceleration through Science Education
Friday, September 23 (am)	Lesson planning 3: Reflection, review and evaluation	ARG EPPI review
Friday, September 23 (pm)	Numeracy	AKSIS Language of maths in science
Tuesday, September 27 (am)	Removing barriers to learning/RSC	
Tuesday, September 27 (pm)	Datalogging	
Thursday, September 29 (am)	Biology 1/Physics 1	

Thursday, September 29 (pm)	Biology 1/Physics 1	
Thursday, October 6 (am)	Practical 2: Science enquiry/Planning for investigations	SAILS and ASSIST-Me Projects
Thursday, October 6 (pm)	Practical 3: How to give a good demo; Risk assessment; Demo day prep	
Friday, October 7 (am)	Chemistry 1/Physics 2	
Friday, October 7 (pm)	Chemistry 1/Physics 2	
Friday, October 14 (am)	Language and literacy	Language & science
Friday, October 14 (pm)	IDEAS	IDEAS project>argumentation
Tuesday, October 18 (am)	Classroom & behaviour management	
Tuesday, October 18 (pm)	Demo day prep time	
Thursday, October 20 (am)	Biology 2/Chemistry 2	
Thursday, October 20 (pm)	Biology 2/Chemistry 2	
Friday, October 21 (am)	AfL2: Feedback	AfL/Black Box
Friday, October 21 (pm)	ASE intro/Practical demonstrations by students	
Monday, December 12 (am)	Show & tell; Target-setting and standards; Introducing the CA	
Monday, December 12 (pm)	Tutorials where needed	

Appendix J: CBM material in core content for ITT

Trainees should have an understanding of a variety of strategies for managing behaviour effectively, including the importance of routines, responses and relationships for ensuring good classroom behaviour. They should learn and practise a range of routines for improving the behaviour of pupils and minimising opportunities for disruption, and understand the importance of communicating clear boundaries and high expectations.

Trainees should also understand how to access whole-school support. Trainees should be able to employ strategies to secure and maintain an orderly classroom, pre-empt disruptive behaviour and continue a lesson after interruption, and understand the importance of body language, clear communication, voice tone and vocabulary. Trainees should practise how to be authoritative and fair, and how to build confidence and regulate their own emotional disposition.

Providers should devise opportunities for the practical demonstration and instruction of these techniques, prioritising opportunities for trainees to reflect, improve and practise at the most appropriate points in their training. Providers should also ensure that trainees are given structured exposure to a variety of classroom contexts, to the observation of best practice and, where possible, pre-course practice sessions.

DfE (2016a:19)

Appendix K: CBM-related material in PGCE programme

	Date	Title	Description
PD programme	14th September	Teen Brains	Lecture given by a neuroscientist presenting material about teenagers' brains which may account for differences in their thinking and behavior from adults
	5th October	Understanding behavior	Lecture given by a colleague from the local authority (LA), whose specialism was in restorative practice (followed by seminar)
	17th October	Managing Pupil Behaviour	Lecture given by an academic with a research interest in behavior, based on Haydn's work on managing pupil behavior, including the 10-point scale (Haydn, 2012; followed by seminar)
	19th October	Behaviour management panel	A panel discussion, where the panel consisted of practising teachers from schools with a range of approaches to CBM, as well as an LA representative (followed by a seminar)
Curriculum programme	13th September	Managing practical work/safety	A seminar led by a science education tutor, which included material about managing resources in science lessons, as well as health and safety, including practical activity
	18th September	Classroom and behavior management	A seminar led by a science education tutor, which included material based on Dreikurs' goal-centred theory, and Rogers' (2011) decisive discipline
	5th February	Intervention session on CBM	I taught an additional seminar on CBM in response to it being raised frequently as a teaching issue by the research participants. Material was based on Plevin's (2011) needs-focused interventions.

Appendix L: Summary of data collected

Date	Data	Pseudonym of student							
		CM	Connor	Dean	Emily	Kathryn	Paul	Rachael	Zoe
Pre-course	UCAS application form		✓	✓	✓	✓	✓	✓	✓
18 Oct 2016	Action Plan		✓						
24 Nov 2016	Teaching Review		✓	✓					✓
12 Dec 2016	Reflective Journal	✓	✓		✓	✓		✓	✓
12 Dec 2016	Action Plan	✓	✓	✓				✓	✓
12 Dec 2016	Critical Incident Analysis	✓		✓	✓	✓	✓	✓	✓
12 Dec 2016	Audio Recording of AL Set	✓	✓	✓	✓	✓	✓	✓	✓
Jan 2017	School placement A consent forms	✓							
Jan/Feb 2017	Reflective Journal				✓	✓			
Jan/Feb 2017	Review of Dec Action Plan	✓	✓	✓		✓			✓
Jan/Feb 2017	Action plan	✓	✓	✓	✓	✓		✓	✓
23 Jan 2017	Critical Incident Analysis		✓	✓			✓	✓	✓
23 Jan 2017	Audio Recording of AL Set	✓	✓	✓			✓	✓	✓
16 Jan 2017	Teaching Report	✓	✓	✓			✓	✓	✓
9 Feb 2017	Audio Recording of AL Set				✓	✓			
19 April 2017	Review of Jan Action Plan	✓					✓		✓
19 April 2017	Action Plan						✓	✓	✓
19 April 2017	Audio Recording of AL Set	✓					✓	✓	✓
6 June 2017	Teaching Report				✓		✓		✓

Appendix M: Ethical approval – Information and consent forms

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study which aims to find out what barriers beginning teachers face during their training year, and to investigate the effectiveness of a method which may support their development.

You have been invited to participate in this study because you have registered as a secondary science PGCE student at [redacted]. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving your consent to take part in this study you are telling us that you:

- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

(2) Who is running the study?

The study is being carried out by the following researchers: Helen Gourlay, Lecturer in Secondary Education (Science), [redacted].

Helen Gourlay is conducting this study as the basis for the degree of Doctorate in Education (EdD) at [redacted]This will take place under the supervision of [redacted].

(3) What will the study involve for me?

You will be asked to keep a 'critical incident diary' (a sort of diary or journal) of anything that happens in the course of teaching practice which seems to you to be important to your progress in becoming a teacher. These incidents are only critical in so far as they seem noteworthy to you – they are often challenges, issues or puzzling events that you would like to resolve about your teaching. I will teach you how to analyse these critical incidents, which may help you to understand them better.
Periodically, at about 6 points in the PGCE year, you will:

- Carry out analysis of the critical incident
- Take part in an action learning set (described below)
- Develop an action plan to overcome your teaching issue

I will make a copy of the critical incident diary and any written analysis that is generated.
It is likely that there will be about 4-8 participants in the action learning set, and the other participants will be your peers from the science PGCE group. The action learning sets will be audio recorded.

The following protocol was trialed at [redacted] during 2015-16:

1. Think of an issue which you have faced related to teaching practice.
2. One by one outline your issue to the rest of the group. The group then chooses one person's issue that they would like to explore further. This person becomes the presenter.
3. The group then decides upon a facilitator who will control the timing and running of the process and help agree a contract between the group.
4. The process begins by the presenter presenting their issue in greater depth.
5. Next, the facilitator will allow the rest of the group to begin one by one asking open questions to encourage the presenter to explore and reflect upon their chosen issue further.
6. The facilitator ends the questioning and asks the presenter to reflect on the conclusions they have made and actions that they plan to take to move on with the issue in light of the process.
7. The whole group will then review the process. What did we do? How did we do? What did we learn?

In this study, each participant will have an opportunity to present their teaching issue. Afterwards, you will be asked to develop a plan to overcome your teaching issue when you return to your school placement. I will be available to support you with developing your action plan.

Whilst you are in your school placement, you may decide to collect data to evaluate the success of your plan. This might include another teacher, beginning teacher or tutor carrying out a written observation of your lesson, focusing on your teaching issue, or collecting a sample of children's work, for example. At the next action learning set, you would give feedback to the group about the degree to which your plan was successfully implemented.

It is anticipated that the action learning sets will take place at [redacted], in one of the rooms used for PGCE teaching. It is likely that they will coincide with the points in the course at which you receive reviews or reports about your teaching from your school mentors (typically November, December, March, May and June).

The audio recordings of the action learning sets will be transcribed and you will have an opportunity to review them and give feedback. Amendments would then be made before publication, where needed.

Because you are a registered student on the PGCE course, I will have access to information about your qualifications and prior experiences, as well as to the reviews, reports, assignment grades and teaching grades during the year.

(4) How much of my time will the study take?

15 mins per week for completing the 'critical incident diary' for 24 weeks: 6 hours
Half a day (3 hours) to attend session at 6 points in the year where we will analyse critical incidents, carry out action learning sets, and develop action plans: 18 hours
Total time: 24 hours

(5) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether or not to participate will not affect your current or future relationship with the researchers or anyone else at [redacted].

If you decide to take part in the study and then change your mind later, you are free to withdraw until the thesis is submitted, which is anticipated to be September 2018. You can do this by contacting the researcher using the contact email address or telephone number

given at the top of this letter. Alternatively you may contact [redacted]

If you take part in an action learning set, you are free to stop participating at any stage or to refuse to answer any of the questions from your peers. However, it will not necessarily be possible to withdraw your individual comments from my records once the group has started, as it is not always possible to work out what was said by whom in a group discussion.

If you decide to withdraw from the study, I will not collect any more information from you. Please let me know at the time when you withdraw what you would like me to do with the information I have collected about you up to that point. If you wish your information will be removed from my study records and will not be included in the study results, up to the point that I have submitted the thesis, which is anticipated to be September 2018. You may contact my supervisor to discuss this if needed.

(6) Are there any risks or costs associated with being in the study?

Because the action learning sets ask you to discuss teaching issues, there is a small possibility of emotional and psychological difficulties being raised. You may access support from [redacted]

Because you are asked to keep a critical incident file, there is the small possibility of you recording thoughts about your attitudes and values which raise questions about your fitness to practice as a teacher. If you are in doubt about any of the content of your file you may refuse to disclose the file to me, and this may be a reason why you would wish to withdraw from the study. If material is disclosed which leads to a disciplinary procedure within the university, for example owing to serious concern about professionalism, or a child protection issue, then there is a possibility that you will not meet the Teachers' Standards and you may have to withdraw from your PGCE studies.

If you think you have been disadvantaged in any way by participating in the study, or by choosing not to participate, you may also contact the Dean of Students.

(7) Are there any benefits associated with being in the study?

Participation in the action learning process may help you because there is an opportunity for you to voice your teaching issues/challenges. Your peers and I may help you to develop strategies to overcome these issues. This may prepare you better for starting work as a teacher. It is also possible that the critical incident analysis and action learning process will enable you to become more reflective about your work as a teacher, and that you will develop greater empathy. It may also help you to develop greater confidence and resilience in preparation for entering the teaching profession, which may have longer-term benefits to you as a teacher.

Science teaching is a shortage area in schools, so if the intervention is successful in supporting you then there is a potential benefit to society. You might also be a better teacher than you would otherwise have been, which would have a positive impact on your students' learning.

(8) What will happen to information about me that is collected during the study?

The types of information that will be collected and used in the study include:

- PGCE course data, such as qualifications and prior experiences, teaching reviews and reports.
- Copies of critical incident diaries and written analysis of critical incidents
- Audio recordings of the action learning sets
- Written action plan documents
- Any data that you provide from teaching practice, such as written records of lesson observations and examples of pupils' work.

The audio recordings will be used for analysis, and excerpts may also be used in publications to provide illustrations of what was said.

Professor [redacted](my supervisor) and I will have access to your information.

You may request to see the information that is held about you by contacting either me or my supervisor.

The study results will be published in a thesis, and in academic or professional journals, and may be published and/or presented at conferences.

By providing your consent, you are agreeing to us collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise. Data management will follow the 1998 Data Protection Act and the [redacted]

Your information will be stored securely in university premises and your identity/information will be kept strictly confidential, except as required by law. Study findings may be published. Although every effort will be made to protect your identity, there is a risk that you might be identifiable in publications due to the nature of the study and/or the results. In this instance, data will be stored for a period of 10 years and then destroyed.

(9) What if I would like further information about the study?

When you have read this information, Helen Gourlay will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact:
[redacted]

(10) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by ticking the relevant box on the consent form. This feedback will be in the form of a one page lay summary. You will receive this feedback after the study is finished.

(11) What if I have a complaint or any concerns about the study?

Research involving humans in UK is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been approved under the regulations of the University [redacted]

If there is a problem please let me know. You can contact me via the University at the following address:

[redacted]

If you would like to speak to someone else you can contact my supervisor:

[redacted]

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the Head of the School

[redacted]

(12) OK, I want to take part – what do I do next?

You need to fill in one copy of the consent form and return it by email to [redacted]

Please keep the letter, information sheet and the 2nd copy of the consent form for your information.

PARTICIPANT CONSENT FORM (1st Copy to Researcher)

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.

✓ The researchers have answered any questions that I had about the study and I am happy with the answers.

✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia now or in the future.

✓ I understand that I can withdraw from the study at any time.

✓ I understand that I may leave the action learning set at any time if I do not wish to continue. I also understand that it will not be possible to withdraw my comments once the group has started as it is a group discussion

✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

✓ I understand that the results of this study may be published. Although every effort will be made to protect my identity, I may be identifiable in these publications due to the nature of the study or results.

I consent to:

- **Audio-recording** YES ☐ NO ☐
- **Reviewing transcripts** YES ☐ NO ☐
- **Would you like to receive feedback about the overall results of this study?** YES ☐ NO ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

☐ Postal: _____

_____

☐ Email: _____

.....
Signature

.....
PRINT name

.....
Date

Appendix N: Information and consent forms – headteachers, pupils and parents

HEADTEACHER INFORMATION STATEMENT

I am conducting this study as the basis for the degree of Doctorate in Education (EdD) at [redacted]This will take place under the supervision of Professor [redacted].

The aim of the study is to evaluate an intervention which is designed to support the professional learning of beginning science teachers. Mr/Ms/Dr [insert name of beginning teacher], who is on placement in your school as part of their PGCE, is a participant in the study. S/he would like to collect some data in the science classroom in order to evaluate the success of his/her plan to improve his/her teaching.

These data may include:
Written notes carried out by another beginning teacher, the class teacher or mentor, or university tutor
A sample of the children's written work
The beginning teachers' written lesson evaluation

Consent will be sought from both the children and their parents or carers.

Information will be kept strictly confidential, except as required by law. Study findings may be published. Every effort will be made to protect the identity of the children and the school. The school will not be named. In this instance, data will be stored in secure university premises for a period of 10 years and then destroyed.

If you would like any further information about the study, please use the contact details at the topic of this letter. Alternatively you may contact my supervisor, Professor [redacted]

HEADTEACHER CONSENT FORM (1st Copy to Researcher)

I, ... [PRINT NAME], give permission to Helen Gourlay to carry out her research project in this school, as described above.

- **Would you like to receive feedback about the overall results of this study?**

YES ☐ NO ☐

If you answered **YES**, please indicate your preferred form of feedback and address:

☐ Postal: _____

_____

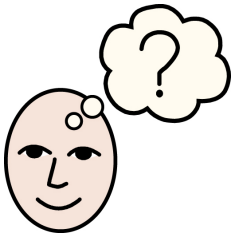
☐ Email: _____

.....
Signature

.....
PRINT name

.....
Date

Study Information Sheet: Supporting the development of science teaching



Hello. My name is Helen Gourlay

I am doing a research study to find out more about science teaching.

I am asking you to be in our study because Mr/Ms/Dr X is taking part in the project and s/he is your science teacher.

You can decide if you want to take part in the study or not. You don't have to - it's up to you.

This sheet tells you what I will ask you to do if you decide to take part in the study. Please read it carefully so that you can make up your mind about whether you want to take part.

If you decide you want to be in the study and then you change your mind later, that's ok. All you need to do is tell me that you don't want to be in the study anymore.

If you have any questions, you can ask us or your family or someone else who looks after you. If you want to, you can call me any time on [redacted].

What will happen if I say that I want to be in the study?

The study will take place in your school science lesson on [insert date].
You will take part in the lesson in the same way that you would normally do and carry out your work in the normal way.
[Select from the following]

- [Name of person & their role] will be observing your lesson and their notes may include comments about how you worked during the lesson, or a note about something that you said or did.
- The teacher might take a photocopy of the written work you completed in the lesson.
- Your teacher might write an evaluation of the lesson afterwards, and this might include something that you said or did during the lesson

Will anyone else know what I said or did in the lesson?

We won't tell anyone else about what you say in the lesson, except if we talk about someone hurting you or about you hurting yourself or someone else. Then we might need to tell someone to keep you and other people safe. We also won't tell anyone what you do in the lesson unless you or someone else gets hurt, in which case we may need to tell someone. We also won't tell anyone what you write about in the lesson, except if you write about someone hurting you, or you hurting yourself or someone else. Then we might need to tell someone to keep you and other people safe.

All of the information that I have about you from the study will be stored in a safe place and I will look after it very carefully. I will write a report about the study and show it to other people but I won't say your name in the report and no one will know that you are in the study.

How long will the study take?

The study will take place in your science lesson, which is X minutes long.

Are there any good things about being in the study?

You won't get anything for being in the study, but you will be helping us do our research.

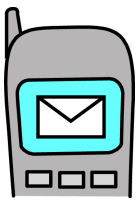
Are there any bad things about being in the study?

This study will take place during your normal science lesson, and I don't think it will be bad for you or cost you anything.

Will you tell me what you learnt in the study at the end?

Yes, I will if you want me to. There is a question on the next page that asks you if you want me to tell you what I learnt in the study. If you circle Yes, when I finish the study I will tell you what I learnt.

What if I am not happy with the study or the people doing the study?



If you are not happy with how we are doing the study or how we treat you, then you or the person who looks after you can contact me at [redacted]

If you would like to speak to someone else you or the person who looks after you can contact my supervisor:

Professor [redacted]

If you or the person who looks after you wish to make a complaint please contact the Head of the School [redacted]

Study Information Sheet: Science teaching
Consent Form 1

If you are happy to be in the study, please

- **write** your **name** in the space below
- **sign** your **name** at the bottom of the next page
- put the **date** at the bottom of the next page.

You should only say 'yes' to being in the study if you know what it is about and you want to be in it. If you don't want to be in the study, don't sign the form.

I, ...[PRINT NAME], am happy to be in this research study.

In saying yes to being in the study, I am saying that:

✓ I know what the study is about.

✓ I know what I will be asked to do.

✓ Someone has talked to me about the study.

✓ My questions have been answered.

✓ I know that I don't have to be in the study if I don't want to.

✓ I know that I can pull out of the study at any time if I don't want to do it anymore.

✓ I know that I don't have to answer any questions that I don't want to answer.

✓ I know that the researchers won't tell anyone what I say in the lesson, unless I talk about being hurt by someone or hurting myself or someone else.

✓ I know that they won't tell anyone what I do, unless I hurt myself or someone else.

✓ I know that they won't tell anyone what I write, unless I write about being hurt by someone or hurting myself or someone else.

Now we are going to ask you if you are happy to do a few other things in the study. Please circle 'Yes' or 'No' to tell us what you would like.

Are you happy for us to **make notes** in the lesson? **Yes** **No**

Are you happy for us to **photocopy** your work? **Yes** **No**

Are you happy for your teacher to **write notes** in their lesson evaluation?

Yes **No**

Do you want us to tell you what we **learnt** in the study? **Yes** **No**

…… ……

Signature **Date**

PARENTAL INFORMATION STATEMENT

What is this study about?

This research study is about science teacher development.

Your child's classroom is the site of this research because Ms/Mr/Dr _____ is participating in the study and s/he is your child's science teacher and s/he is taking part in a research study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to let your child take part in the research or not. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is assumed to be consented ***UNLESS*** you tell us otherwise by opting out of the process. If we do not receive an indication from you that you ***do not want*** your child to be part of this research we take that you are giving your consent and you are telling us that you:

- ✓ Understand what you have read.
- ✓ Agree for your child to take part in the research study as outlined below.
- ✓ Agree to the use of your child's personal information as described.

Who is running the study?

The study is being carried out by the following researchers: Helen Gourlay, Lecturer in Secondary Education (Science), [redacted].

Helen Gourlay is conducting this study as the basis for the degree of Doctorate in Education (EdD) at [redacted]. This will take place under the supervision of Professor [redacted].

What will the study involve?

The purpose of the activity is to help the teacher to think about their teaching, and not to make judgments about your child. Your child will take place in their science lesson and complete their work in the normal way.

[Teacher to delete as applicable]

- Another teacher or university tutor will observe the lesson and they may make notes about what your child says or does during the lesson
- Your child's teacher may keep a photocopy of their work and show it to the researcher and other science teachers
- Your child's teacher may write a lesson evaluation after the lesson and they may write something about what your child said or did during the lesson

If you decide not to participate, then your child will still take part in their lesson in the normal way, but no notes will be taken about what they say or do, and no copies of their work will be taken.

How much of my time will the study take?

The study will take place during the science lesson, which is a period of _____ minutes.

Does my child have to be in the study? Can they withdraw from the study once they've started?

Consent to being in this study is assumed unless you tell us otherwise but your child does not have to take part. Your decision whether to let them participate will not affect your current or future relationship with the researchers or anyone else at [redacted].

If you do decide to let your child take part in the study and then change your mind later (or they no longer wish to take part), they are free to withdraw at any time. You are free to withdraw until the thesis is submitted, which is anticipated to be September 2018. You can do this by contacting the researcher using the contact email address or telephone number given at the top of this letter. Alternatively you may contact Professor [redacted]

Are there any risks or costs associated with being in the study?
We do not expect that there will be any risks or costs associated with taking part in this study for your child.

Are there any benefits associated with being in the study? We anticipate that the study may help teachers to develop their science teaching, and hence there is some possibility of a positive impact on children's learning in science.

What will happen to information that is collected during the study?

By providing your consent, you are agreeing to us collecting information about your child for the purposes of this research study. Their information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise. Data management will follow the 1998 Data Protection Act and the [redacted] Research Data Management Policy (2013). Your child's information will be stored securely and their identity/information will be kept strictly confidential, except as required by law. Study findings may be published, but they will not be identified in these publications if they decide to participate in this study. In this instance, data will be stored for a period of 10 years and then destroyed.

What if we would like further information about the study?

When you have read this information, Ms/Mr/Dr _____ [the science teacher] will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact Helen Gourlay, [redacted].

What if we have a complaint or any concerns about the study?

Research involving humans in UK is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have been

approved under the regulations of the University of East Anglia's School of Education and Lifelong Learning Research Ethics Committee.

If there is a problem please let me know. You can contact me via the University at the following address:
Helen Gourlay
[redacted]
If you would like to speak to someone else you can contact my supervisor:
Professor [redacted] (supervisor), [redacted]

If you (or your child) are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact please contact the Head [redacted]

OK, I'm happy for my child to take part – what do I do next?

You don't need to do anything if you are happy for your child to participate. Please keep the information sheet for your details regarding the project and how to get in touch with the researcher if you need to.

OK, I don't want my child to take part – what do I do next?

You need to fill in one copy of the consent form and return it to Ms/Mr/Dr _____ [the science teacher] at _____ [school] by _____ [date]. Please keep the letter, information sheet and the 2nd copy of the consent form for your information.

PARENT/CARER CONSENT FORM (1st Copy to Researcher)

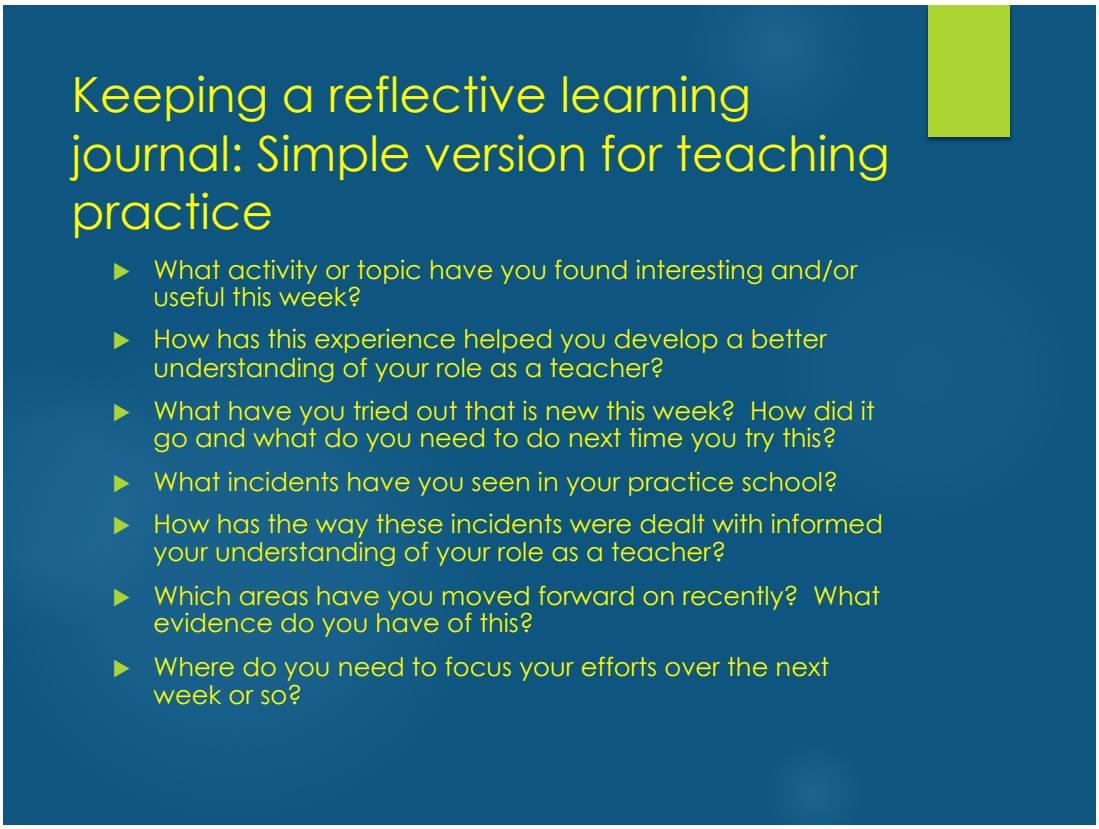
I, ... [PRINT PARENT'S/CARER'S NAME], **am not willing** for my child ……[PRINT CHILD'S NAME] to take part in this research study.

.....
Signature

.....
PRINT name

.....
Date

Appendix O: Reflective journal guidance 1



Originally taught on the PGCE programme at King's College London

Appendix P: Reflective journal guidance 2

Keeping a learning journal (reflective diary)

Why
Reflecting on what works well in your studies and in the classroom helps you to develop your study skills, as you try out different approaches and review their effectiveness. It is easy to become stuck in a study routine that is not effective for the task in hand. Thinking about your own learning skills and being aware of those you tend to use may help you to

- see how you might make changes
- develop new ways of working
- become more aware of the different techniques you could devise.

Reflection has an important role to play in learning and self-development. There are some key elements of reflection, and you'll need decide on your preferred ways. Reflection could be described as

- thinking with a purpose
- being critical, but not negative
- analysing how effective your learning is
- questioning and probing
- making judgments and drawing conclusions.

How

- Write in your journal regularly, even if individual entries are sometimes short
- Focus on a specific event or issue for an individual entry – think about how you could address or resolve the issue, or what you'd like to improve
- Avoid descriptive writing, take an analytical approach
- Use techniques such as mind mapping, diagrams, sketches or cartoons. Use colour to make these more engaging and memorable
- Review the entries that you've written to see if you can find key themes and recognise what longer-term action you might need to take (e.g. to improve a particular skill)
- Remember that writing itself can be used as a learning tool: you can use writing to explore ideas as a way of understanding them.
- Use questions or prompts to help you focus on the task

Later
During the course of research I will take a copy of the journal, with your permission. You may find it helpful to refer to your journal in university sessions where we reflect on teaching issues, and carry out action learning sets.

Ideas for getting started on reflective writing:
1. General approaches

- Identify a current problem or issue, describing it in context.
- Who or what could help with the problem or issue?
- What are my assumptions? How can I test them?
- What can I do to create a change?
- What action will I take? Why?
- List the outcomes that you hope to achieve.
- Reflect on an actual outcome. What worked well? What did pupils learn or not learn? What could I do differently next time?

2. Focus on the experience and think (not aloud) in writing

Take something you have read in the literature on teaching and learning, or take something that occurred as part of your activities undertaking this course and use the following questions to guide your reflection:

- How does this connect with an aspect of my practice?
- What are the teaching and learning principles that are involved?
- What could I change in relation to this?
- What would happen if I did?

3. Focus on a critical incident that took place in your classroom

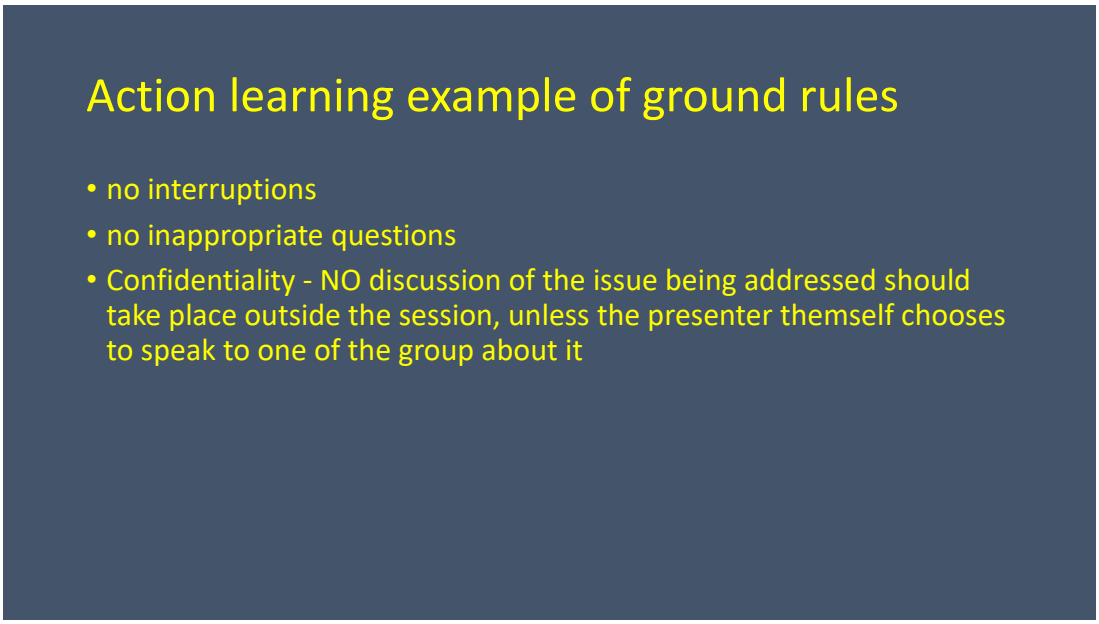
- Describe the incident as objectively as possible.
- What were the assumptions that you were operating with?
- Is there another way to see this event?
- How would your students explain this event?
- How do the two explanations compare?
- What could you do differently?

4. Taking stock of my learning

- What is the most important thing I have recently learnt?
- How can I use my recent learning to improve student learning in my classes?

Adapted from a resource used on a Subject Knowledge Enhancement course in Physics at UCL Institute of Education.

Appendix Q: Ground rules for AL sets



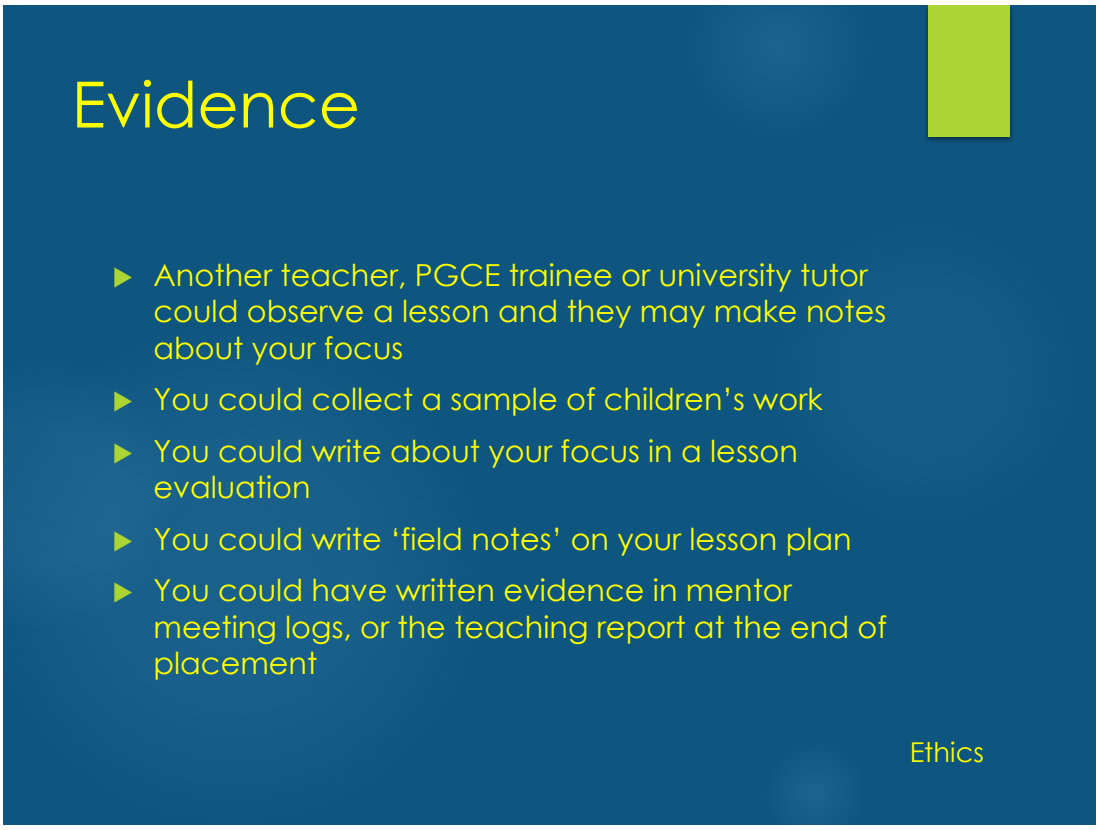
Bayley (2015)

SAMPLE POST PRIMARY INDUCTION ACTION PLAN TEMPLATE: USE OF A RANGE OF TEACHING STRATEGIES

NOTE: *This generic sample action plan does not reference any particular class. Therefore, when drawing up your own action plan, it is advisable to contextualise it to the target class and include an overarching aim for your planned series of lessons in the 'area for development' column along with your selected teacher competence(s).*

Area(s) for Development (Ref to Competences)	Success Criteria	Actions (Including timescales)	Support Arrangements	Monitoring (Inc evidence in portfolio)
To promote high quality learning and achievement for my pupils in Year … on the theme of … in … (subject/AOL) through the effective and creative use of a range of stimulating strategies and resources. **Competence 20** Teachers will use a range of teaching strategies and resources… effectively… including e-Learning where appropriate, that promote high levels of learning and achievement, … motivate and support all pupils learning …, capture and maintain pupils' attention, interest and involvement and ensure good pace … within lessons and over time.	As a result of this action plan: • My lesson planning, organisation and delivery will show evidence of well considered, effective and creative use of a range of teaching strategies and resources aimed at: ➢ promoting good pace in my lesson activities ➢ increasing my Year … pupils' interest in and motivation for my Area of Learning ➢ supporting and extending my pupils' learning • My pupils will: ➢ have successfully participated in a variety of stimulating learning activities ➢ be demonstrating greater enjoyment and satisfaction for my Area of Learning	I will: • Ensure that I become familiar with: ➢ all of the available resources within my department ➢ the departmental policy and scheme of work for Year … ➢ examples of tried and tested strategies identified in discussion with other BTs and colleagues within school and as a result of personal reading and research ➢ the good practice of other departmental colleagues • Plan and deliver a series of lessons to reflect good and varied use of a range of effective strategies and resources • Attend: ➢ regional ELB BT INSET for my Area of	I will wish to: • Consult with my HOD and departmental colleagues regarding existing learning and teaching resources and the possible acquisition of any additional materials which may enhance both my own and their professional practice • Enlist the support of my HOD and other colleagues to engage in classroom observation and post observation reflective discussion • Liaise with colleagues regarding the appropriateness of resources and strategies identified/developed for inclusion in action plan and lesson plans • Secure BT substitute cover to attend ELB INSET	Examples of the following will be placed in my Induction portfolio as evidence of my ongoing monitoring: • Sample lesson plans • Examples of teaching strategies and resources developed/selected to motivate, support and challenge pupils' learning • Log(s) of significant professional learning points arising out of: ➢ my planning discussions with my Teacher Tutor/HOD/AOL colleagues/ELB support officers ➢ my observation of colleagues use of strategies and resources ➢ my observation of pupils engagement with selected strategies and resources • Samples of pupil feedback and completed work (*consider podcasts, videos, written and*

Appendix S: Suggested evidence



Appendix T: Summary of teaching intervention

Date	Description
18 Oct 2016	Introductory seminar 'Critical incidents in teaching and action learning'. Introduction to: - Reflective journals - Critical incident analysis - Diagnostic teaching cycle - AL set - Action plans Students invited to take part in study: The research is explained, students given information sheets and consent forms.
12 Dec 2016	Seminar 'Action learning revisited'. Students: - Write critical incident analysis - Carry out AL set - Write action plan Introduction to obtaining ethical approval to collect evidence in school.
23 Jan 2017	Seminar: 'Group tutorial: Reflective writing and action learning'. (My tutor group only). Students: - Review action plans - Learn about features of reflective writing - Write critical incident analyses - Carry out AL set - Write action plan
9 Feb 2017	Seminar: Repeat of the session above with the other tutor group. Students: - Review action plan - Carry out AL set - Write action plan
19 Apr 2017	Seminar: 'Developing reflective practice using critical incident analysis and action learning'. Students: - Review action plans - Carry out an AL set - Write action plans

Appendix U: Connor's list

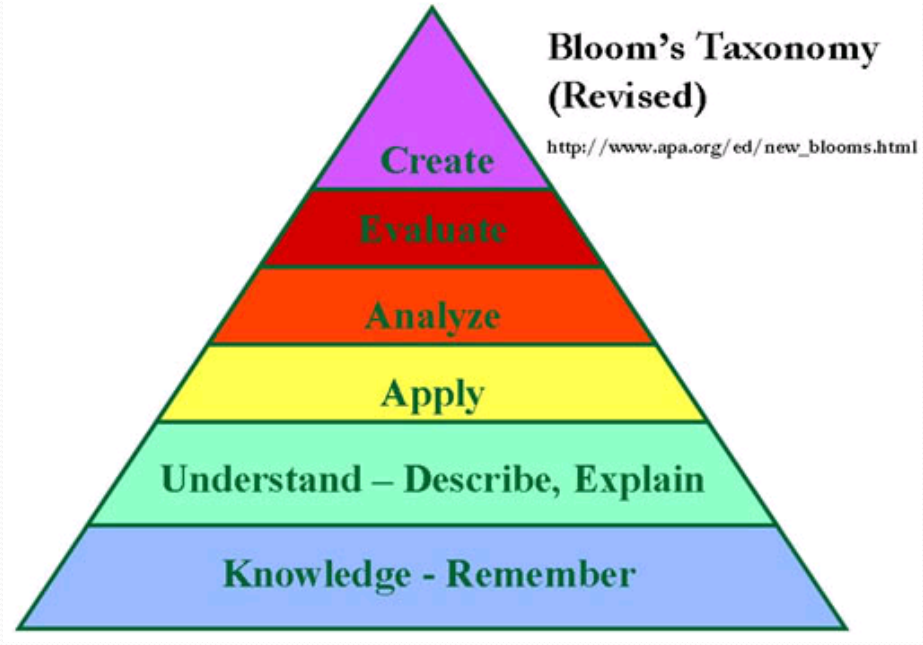
Connor submitted this material as his reflective journal in the autumn term:

Reflective Journal

- Have some questions or an activity on the board to give them something to do as the kids walk in.
- Have an All should know this, Most should know this, and Some should know this at the start as a sort of setting learning targets for the class. (use level 4, 6, 8 for GCSE
- Make sure everyone can see a demonstration
- Be more harsh with punishment and follow up on threats faster
- Confiscate phones when they are out in class and shouldn't be
- Don't wait for kids to catch up, just move on
- Wait for classes to quiet down to move on
- Come up with a transition method
- Write instructions for task and extension clearly on the board
- Set up beforehand
- Don't give them time to get off task, keep them busy
- When waiting silently, let them know somehow (not by yelling, defeats the purpose)
- Put extra things at the end or make them skippable if running low on time
- Make sure they understand why they are doing the practical
- Have them do something over teacher talk or Q and A
- Give detentions to get work done if they don't do any in class
- Give detentions for not doing homework
- Even when doing a fun activity, everyone has to be doing something
- Give them a rant if they keep talking, they need to show respect
- Make sure they have something to show they did work at the end
- Set them easy, medium, hard work. Assign it or let them pick depending on the class

Appendix V: Science Curriculum Seminar – Bloom's Taxonomy

Bloom's taxonomy



Bloom's Taxonomy

For ONE of the following topics

Reactivity Series

Earth and Space

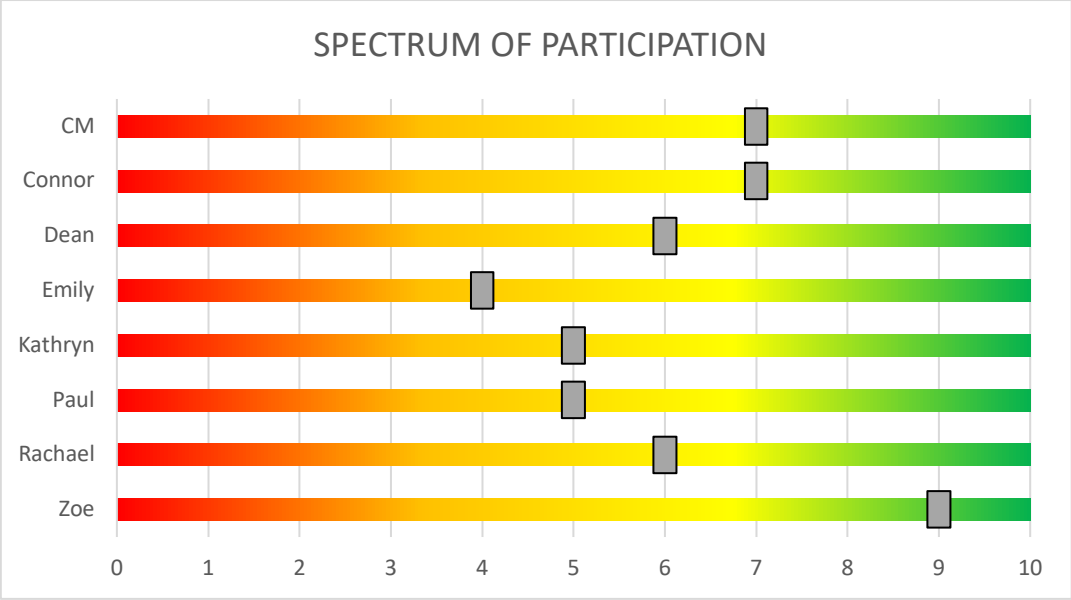
Digestion

CREATE questions for each of the categories in Bloom's Taxonomy

Originally taught as part of the PGCE at King's College London

Appendix W: Spectrum of participation

PARTICIPANT	Participation SCORE/10
CM	7
Connor	7
Dean	6
Emily	4
Kathryn	5
Paul	5
Rachael	6
Zoe	9



Appendix X: Summary of the emotional dimension

		Participant							
AL set	Code	Zoe	Connor	CM	Paul	Dean	Rachael	Kathryn	Emily
Dec 2016	TF	2	1	3	1	4	0	1	4
	PF	0	1	0	0	0	2	2	0
Jan/Feb 2017	TF	3	1	3	3	0	1	5	2
	PF	0	3	0	1	5	1	0	0
	Total	5	6	6	5	9	4	8	6

Appendix V: Descriptions of the predominant categories used for coding

Category	Description
Assessment	Obtaining feedback from pupils. Where formative, assessment information is used to inform future teaching. (Black *et al.*, 2004))
CBM	Creating an environment in which learning is maximized; and having a working atmosphere in the classroom that allows pupils to learn (Ch.2.5.2)
Engagement	A term used by participants, concerning pupils actively participating in the lesson.
Inclusion	Concerning reducing barriers to learning, such as differentiation and attending to the needs of pupils with special educational needs and disabilities (Capel, Leask & Turner, 2009)
Mentoring relationships	Concerning participants' interactions with class teachers, mentors and technicians who were working with them in schools
Pupil feelings	Statements in which participants attributed feeling states to their pupils, such as 'happy', 'sad', etc.
Subject content knowledge	Statements in which participants expressed concern about not knowing the subject matter that they needed to teach to pupils
Teacher feelings	Neuroscientists now tend to view feelings as 'the mental representation of the physiological changes that characterize emotions' (Damasio, 2001). Including statements such as 'I hate two of my classes' as feelings rather than emotions (which are physiological responses)
Time management	Encompassing a range of concerns to do with time, from pupils taking different amounts of time to complete work to the teacher needing to use a timer to keep tasks to an allotted amount of time

Appendix Z: Examples of participants giving advice in AL sets

AL set	Theme	Student	Advice	Student giving advice
December: Connor, CM, Dean, Paul, Zoe	CBM	Zoe	Use two different levels of voice so that pupils know when you are serious	Paul
		Connor	Talk to the pupil outside the room	Dean
		CM	Talk to the pupil one-to-one	Paul
		Dean	Try out being a strict teacher	Connor
	Too many targets	Paul	Tell the class teacher what you are focusing on so that they can give feedback on that one thing	Dean
January: Connor, CM, Dean, Paul, Rachael, Zoe	CBM	CM, Zoe	Use a behaviour contract	Dean
		Rachael	Do a demonstration instead of class practical work	CM
	Assessment	Dean	Use exit tickets	CM
April: CM, Paul, Rachael, Zoe	Assessment	Rachael	Consult [named colleague] about how to set up PowerPoint so questions in notes can be seen by teacher	Zoe
		Zoe	When going through a summative test, point out transferable skills to pupils	Rachael
	CBM	Paul	Use countdown timer to create time pressure	CM
			Make greater use of praise	CM
			Give pupils a task where they have to present back to the rest of the class	Zoe

Appendix AA: Topics to teach science PSTs in ITE

This list is broadly based on the frequency with which the topics were mentioned by participants:

1. Classroom and behaviour management
    a. Dealing with low-level disruption
    b. Dealing with confrontation/conflict (pupil-teacher and pupil-pupil), defusing situations
    c. Developing classroom presence, use of voice and body language
    d. Having clear routines and expectations
    e. Using stepped approaches, including sanctions
    f. Holding pupils in unconditional positive regard
    g. Teaching adolescents (and how this might be different than younger students and sixth formers; linked to motivating pupils and building a rapport)
    h. Dealing with 'smart Alecs'
    i. Planning appropriately structured lessons
    j. Building a rapport
    k. Learning names
    l. Developing own strategy (strategies) for managing behaviour if school policy not obvious
    m. Dealing with extreme behaviour incidents, such as a violent outburst
2. Motivating pupils
    a. Lesson structure and timing
    b. Variety of activities
    c. Praise and rewards (benefits and drawbacks)
3. Differentiating, in particular how to manage 'mixed ability' classes
4. Strategies for teaching topics that don't have much practical work, including electron configurations, bonding and sexual reproduction (might link to uses of ICT)
5. Making productive use of assessment
    a. Oral questioning
    b. Using mini whiteboards, including how to count out and count in equipment
    c. Other methods for finding out what pupils understand (might link to uses of ICT)
    d. How to use assessment information to inform future teaching
6. Managing your mentor and class teachers
7. Managing practical work
    a. Giving clear instructions
    b. Short, structured practical work vs open-ended enquiry
    c. Putting pupils into groups
    d. Giving out and collecting in resources
    e. Opportunities to practice demonstrations and experiments prior to teaching
    f. Linking the practical work to the ideas about science that pupils are meant to be learning
8. Teaching physics topics
9. Teaching chemistry topics
10. Using ICT to support teaching
    a. Powerpoint(lessness)
    b. Kahoot! And Plickers (linked to assessment)

c. Managing internet searches