

“Walking the Line Between Structure and Freedom”

**A Case Study of Teachers’ Responses to Curriculum Change using Complexity
Theory**

**Submitted by Lindsay Ellen Joan Hetherington to the University of Exeter for
the degree of**

Doctor of Philosophy in Education

In May 2012

This thesis is available for Library use on the understanding that it is copyright material and
that no quotation from the thesis may be published without proper acknowledgement.

I certify that all material in this thesis which is not my own work has been identified and that
no material has previously been submitted and approved for the award of a degree by this
or any other University.

Signature:

Abstract

This thesis uses complexity theory to explore education in the context of a changing curriculum called 'Opening Minds'. This new curriculum was introduced in the case study school in response to a wider curriculum change which emphasised 'learning to learn' and the development of 'skills for the 21st Century'. In this study, a 'complexity thinking' theoretical framework was adopted, drawing especially on the work of Osberg and Biesta (Osberg et al., 2008, Osberg and Biesta, 2007, Biesta and Osberg, 2007) and Davis and Sumara (2006; 2007), paying particular attention to concepts of emergence and complexity reduction. Complexity theory, through the 'logic of emergence' offers a challenge to mechanistic approaches to understanding the world which, despite the work of postmodern and poststructural scholars in education, remains dominant in educational practice. The Opening Minds curriculum that is the focus of this case study demonstrated the potential to challenge this mechanistic approach, as the teachers expressed a desire to work in different, flexible and creative ways: this thesis therefore explores complexity theory's challenge to a mechanistic approach in this particular case. It also addresses the relationship between Opening Minds and science education using complexity thinking. To facilitate exploration and analysis of the case, concepts of temporal and relational emergence and complexity reduction to develop a 'complexity thinking' understanding of concepts of agency/structure, power, identity and reflexivity. This entailed reconceptualisation of these ideas in a temporal-relational sense that explicitly incorporates a sensitivity to emergence. Specifically, an additional dimension to Emirbayer and Mische's (1998) construction of multidimensional agency was added: that of creative agency.

The research was conducted as a case study in which a 'bricolage' approach to data collection and analysis was used as part of an explicitly 'complex' methodology, addressing questions of the challenge of complexity reduction and ethics in research drawing on complexity theory. The findings indicated a challenge for teachers in negotiating tensions as they attempted to adopt approaches that could be considered 'emergent' *alongside* other 'mechanistic' practices. These tensions were explored in detail in relation to the concept of 'reflection', and in the interaction between science and Opening Minds. Bringing together the empirical and theoretical work in this study, it is suggested that mechanistic and emergent aspects may helpfully be viewed as a 'vital simultaneity' within the educational

relationship (Davis, 2008) with the interaction between them facilitated by creative agency within a 'pedagogy of interruption' (Biesta, 2006). It was further argued that reflection could be used in responsive and flexible ways to support both learning and assessment as a crucial aspect of a pedagogy of interruption. Such a 'contingently responsive and creative pedagogy' may support the interaction between science and Opening Minds productively. It is suggested that complex approach to a pedagogy of interruption could support teachers in engaging with the creative and diverse elements of science or learning to learn curricula whilst maintaining the mechanistic aspects of teaching that support students in learning key concepts and skills.

Table of Contents

Abstract.....	3
List of Tables/Illustrations.....	9
List of Accompanying Material	10
Acknowledgements.....	11
Chapter 1 - Introduction: The Initial Space of the Possible	12
1.1 Introduction	12
1.2 Complexity Theory	14
1.3 Changing curriculum context	19
1.3.1 Education and curriculum policy in the UK.....	23
1.3.2 Influences on the culture of education in the UK.....	24
1.3.3 'Learning to Learn'	26
1.3.4 'How Science Works'	31
1.4 Rationale for the study	35
Chapter 2 - Developing a Complexity Theoretical Framework.....	38
2.1 Introduction	38
2.2 Complexity theory and education	41
2.2.1 Critiques of complexity theory as applied to education settings.....	41
2.2.2 Developing 'complexity thinking' in education	47
2.3 A Complexity theoretical framework for researching a case of curriculum change .	53
2.3.1 Relational emergence	53
2.3.2 Temporal emergence.....	55
2.3.3 Complexity Reduction.....	64
2.4 Summary	73
Chapter 3 - Complexity Thinking and Social Theory	74
3.1 Introduction	74

3.2 Agency.....	77
3.3 Reflexivity.....	89
3.4 Power	93
3.5 Identity/Subjectivity.....	96
3.6 Summary	100
Chapter 4 - Methodology.....	101
4.1 Introduction	101
4.2 ‘Complexity Thinking’ Methodology.....	102
4.2.1 Complexity reduction and methodology	107
4.2.2 ‘Relational’ considerations.....	109
4.2.3 ‘Temporal’ considerations	114
4.2.4 Drawing together relational and temporal.....	115
4.2.5 Validity, Rigour and Trustworthiness in Complexity-based research.....	118
4.2.6 Responsible, responsive and ethical complexity-based research	121
4.3 A Case Study of Curriculum Change.....	125
4.3.1 Data Collection.....	125
4.3.2 Analysis	131
4.3.3 Analysis	131
4.3.4 Ethical Procedures	138
Chapter 5 - Findings: Describing the Case	141
5.1 Introduction	141
5.2 Diagrammatic interpretation of the case	142
5.3 Describing the case	144
5.3.1 The School.....	144
5.3.2 The Opening Minds curriculum-as-planned	146
5.3.3 The Opening Minds Team.....	151
5.3.4 The School Leadership	153

5.3.5 The Science Department.....	154
5.3.6 Year Groups and Tutor Groups	155
Chapter 6 Analysis and Interpretation.....	158
6.1 Introduction	158
6.2 Teachers’ beliefs about education.....	160
6.2.1 Education is about developing skills	160
6.2.2 Education is about knowledge.....	165
6.2.3 Education is about raising aspirations and helping children realise them	167
6.2.4 Education is about thinking and questioning	169
6.2.5 Teacher’s Beliefs about Education – Summary	170
6.3 Ideas about Opening Minds.....	171
6.3.1 Opening Minds is about posters and presentations.....	172
6.3.2 Opening Minds is about transferrable skills	176
6.3.3 Opening Minds is different: looser and less constrained	178
6.3.4 OM is about breaking down barriers between subjects	182
6.3.5 Opening Minds is about thinking, process, metacognition and reflection	186
6.3.6 Opening Minds encourages student discussion and questioning	189
6.3.7 Ideas about Opening Minds – summary.....	195
6.4 Reflection and assessment in Opening Minds.....	196
6.4.1 Student reflection and the language of Opening Minds	197
6.4.2 Developing reflection as a form of assessment in OM.....	205
6.4.3 Summary of reflection in Opening Minds.....	209
6.4 Relationship between science and OM	209
6.4.1 Science at Bridge Community School	210
6.4.2 Science teacher’s perceptions of Opening Minds	212
6.4.3 OM teachers perceptions of science in relation to OM	218

6.4.4 Summary of relationship between science and Opening Minds.....	223
6.5 Analysis and interpretation summary	223
Chapter 7 Discussion.....	225
7.1 Introduction	225
7.2 Mechanistic and emergent approaches in tension	227
7.2.1 Tension between facilitation of agency and learning skills	229
7.2.2 Opening Minds, Opening Mouths.....	232
7.3.3 Contingently responsive and creative teaching.....	238
7.3 Tensions in use of ‘reflection’	240
7.3.1 Reflection-as-process.....	242
7.3.2 Reflection-as-interaction	244
7.3.3 Reflection-as-assessment	246
7.3.4 Reflection-as-action	247
7.4 Tensions between science and Opening Minds	250
7.5 Summary	254
Chapter 8 - Summary	256
8.1 Introduction	256
8.2 Summary and implications	256
8.3 Reflection on methodology and design.....	259
8.4 Thoughts about further exploration	263
List of References.....	265

List of Tables/Illustrations

Box 1: Characteristics of complex adaptive systems, drawing on Cilliers (1998) and Davis and Sumara (2006).....	17
Table 1: Discourses of curriculum policy (Moore and Young 2001).....	25
Table 2: Learning theories in relation to 'learning to learn'.	27
Figure 1: The Big Picture of the National Curriculum.	30
Table 3: Summary of the KS3 national curriculum for science.....	32
Figure 2: Visualisations of complex systems, taken from Davis and Sumara (2012), p. 31	43
Figure 3: Visual representation of a complex systems view of a learner in higher education, taken from Haggis (2008).	44
Table 4: Conditions for Emergence drawn from Davis and Sumara (2006) Chapter 7	52
Figure 4: Sketch of possible 'trajectories' of complex dynamic system	59
Figure 5: 'Enlarging the Space of the Possible', after Rasmussen (2010).....	69
Box 2: Example of agency/structure in complex terms.....	82
Table 5: Timescale of data collection in context.	128
Figure 6: Diagrammatic representation of the case	143
Table 6: List of OM topics	149
Table 7: The 'CLIPS' competencies underpinning the new Opening Minds curriculum.....	150
Figure 7: Students who had studied OM were significantly more likely to respond that 'doing a presentation helped them learn'.	174
Figure 8: Tag cloud of responses to open question, 'what do you do in Opening Minds'	175
Figure 9: Images of the national curriculum.....	182
Box 3: Extract from Lesson Observation Notes; Kate's Opening Minds lesson, 11/6/10.	192
Box 4: Extract from staff journal article about OM, by Declan in 08-09	198
Box 5: Examples of using CLIPS in lesson objectives during OM lessons.	201
Figure 10: Self-assessing my work.	207
Figure 11: Peer assessment.	208
Table 8: Mean values of science teacher's responses to Teacher Questionnaire.....	212
Figure 12: Nested levels of schooling, adapted from Davis and Sumara (2006).....	237
Figure 13: Network shapes, adapted from Davis and Sumara (2006) p. 52.....	237

List of Accompanying Material

Appendix 1: Annotated examples of interview schedules: teacher and student

Appendix 2: Lesson observation schedules

Appendix 3: Questionnaires and associated procedures

Appendix 4: Example of matrix analysis

Appendix 5: Certificate of ethical approval

Appendix 6: Example of coding process

Appendix 7: Sketch of data

Appendix 8: Coding Manual

Acknowledgements

This thesis was undertaken within my role at Exeter as a Teacher Education Research Fellow and I am indebted to Debbie Myhill and the Graduate School of Education for creating these fellowships and giving me this opportunity. I am grateful to the staff and students in my case study school who generously gave their time. Thanks also to those teachers and students who talked to me during the pilot phases of the work that are not reported here.

I could not have achieved this work without the support and faith of my supervisors, Deborah Osberg and Keith Postlethwaite. They are both inspirational, and have challenged and supported me all the way, keeping me thinking and helping me to balance the demands of my PhD against the other demands on my time.

My friend Susi has given endlessly of her time to help me practically with this work, including free access to her transcription and proof-reading services.

My colleagues at work have been unfailingly supportive and have regularly given me invaluable informal guidance, cheered me up, cheered me on, and helped me develop a coffee habit in staff house. Nick Givens, my TERF mentor and all-around good guy, Ro Hopper, supplier of tea, biscuits and advice, and my fellow TERFS past and present deserve special mention – Jane and Mary started this journey with me and Jim and Tom joined me on the way. I couldn't ask for better colleagues and friends than Nigel Skinner and Keith Postlethwaite, who have gone above and beyond in helping me, both in my research and with the science PGCE. I owe you guys!

Thanks to all the friends and family who have reminded me to take a break every now and again, including Chris, Alison and Bethan, Joan and Barry, Colin and Rebecca, and Trev. Thanks also go to James and Sue for putting me up during my visits to the British Library and to my parents for the support they have given me throughout my life that has helped me reach this point with especial thanks to Mum for all her efforts in proof-reading and cheerleading.

Finally, I could not have got through the last few years without my family at home. My partner Rich and closest friend Susi have been with me every step of the way. They have given me so much it is impossible to put into words. Thank you for everything.

Chapter 1 - Introduction: The Initial Space of the Possible

1.1 Introduction

We use the term not-yet-imaginable to refer to that space of possibilities that is opened up through the exploration of the current space of the possible. By definition, the not-yet-imaginable is impossible to specify and difficult to describe. It is not a realm of unthinkable thoughts but, rather, thoughts that cannot yet be triggered. (Davis and Sumara, 2007 p. 58.)

This thesis presents an exploration of curriculum change from the perspective of complexity theory. I use the term 'exploration' deliberately, because the work did not seek out an answer to a pre-defined research question, but rather brought together a number of different theoretical and empirical elements to enable me to think differently about responses to a changing curriculum. Using a complex epistemology required a fundamental shift in thinking away from linear and reductionist ways of understanding which identify a particular deficit in current knowledge and design ways to address that deficit. As a result, this work does not follow a standard thesis model in which a gap in knowledge is identified and research questions formulated and answered. Instead, the work employs a change in thinking towards a stance that is open to emergence, and explores current practices by bringing different ideas into dialogue in order to produce something new. Complexity theorists have used the term 'enlarging the space of the possible' (Osberg, 2009a, Sumara and Davis, 1997, Davis and Phelps, 2007) to refer to such emergent thinking. In this thesis, the contribution to knowledge comes from my attempt to enlarge the space of the possible around practices related to a specific movement in curriculum change in the UK (Learning to Learn).

This introductory chapter therefore provides a brief account of the fields of educational policy, practice and research which constituted a starting point for the research. Taking this as the 'ground' from which the exploration undertaken in the empirical study and subsequent analysis was undertaken, I introduce the conceptualisation of the research area (loosely defined) and begin to offer a critical analysis, rooted in complexity thinking, of the educational approaches dominating current policy, practice and research. At the same time, the starting point and initial 'space of the possible' for this work originated in the personal

experience and interests I brought to my PhD. These play an important role in the meaning-making constructed through the research process presented in the thesis. The introduction therefore also includes an account and analysis of my own experiences and positioning within the research field.

Having worked as a classroom science teacher for five years before beginning work at Exeter University as a Teacher Education Research Fellow and PhD student, I developed an interest in how children learn and how they could be helped to improve their skills as learners. I felt that 'learning as an exploration' linked closely to my concept of science, and I was also frustrated that science in schools more often than not appeared to be seen as a body of knowledge to be understood rather than an active and exciting way of finding out about the world. During the short time I had been teaching, I also found that there was no 'right' way to teach. Every class was different and rather than learning what good teaching looked like and then following that pattern, I found I had to be adaptable, flexible and responsive to the needs of my different students and different classes. Teaching the same topic to three separate classes one year showed me that trying the same teaching strategy in the same way with all three led to vastly different results, and I was interested in how this linked to learning. Finally, my background in earth science initially led me to research in that particular part of science education, and I became interested in systems approaches to thinking about earth systems education in particular, and education in general. Exploring these ideas took me to reading about conceptual change, constructivism and sociocultural theories of learning, and also to complexity theory. I found complexity theory particularly appealing as I worked through the MSc research methods course which was part of my doctoral programme, as I felt that much of the time, experimental models of research using a scientific approach did not seem suitable to education because I knew from my own teaching experience that classrooms are messy, unpredictable places – not only are there too many variables to control, it is difficult even to identify which variables need to be considered. Complexity theory, rooted in the natural sciences, appeared to me to provide a comfortable starting point for attempting to work *with* the messiness of the classroom rather than trying to control (or ignore) it. Finally, having experienced the difficulties of a change in the 14-16 curriculum whilst I was teaching, I was interested in how the broader curriculum change that was the policy direction at the time would be experienced in

schools. In particular, I wanted to find out more about how the greater flexibility and adaptability the new 11-14 curriculum might play out in the school environment in relation to science education and in relation to the 'learning to learn' projects that were rapidly becoming part of educational discourse. The main areas forming the ground from which this thesis developed were therefore complexity theory, curriculum change, science education, and the 'learning to learn' curriculum. In the remainder of this chapter, I provide a necessarily brief account of policy, practice and research in these areas in order to clarify the rationale for the study as it was undertaken.

1.2 Complexity Theory

In 1992, Waldrop described the science of complexity as 'a subject so new and so wide-ranging that nobody quite knows how to define it' (Waldrop, 1992 p. 9). Twenty years later, complexity is still difficult to define, in part due to the diversity of disciplines exploring and applying 'complexity science'. Heylighen et al. argue that complexity science is 'little more than an amalgam of methods, models and metaphors from a variety of disciplines' (Heylighen et al., 2007 p. 117) but that what these have in common is a way of thinking that is 'intrinsically different from that of traditional science'. This includes a move away from the reductionism and determinism characterising traditional (Newtonian) science. Prigogine, a theoretical chemist and influential thinker in the field of complexity theory, described this change in thinking thus:

We are observing the birth of a science that is no longer limited to idealized and simplified situations but reflects the complexity of the real world, a science that views us and our creativity as part of a fundamental trend present at all levels of nature. (Prigogine, 1997 p. 7)

Since the 'scientific revolution' of the Enlightenment, the pursuit of science has been dominated by a mechanistic, rational understanding of the universe advocated by Newton and Descartes. This 'clockwork universe', governed by fundamental physical laws which can be discerned by the application of human reason, proceeds in a determined, cause-effect manner. It is the work of science to find out these laws so that the universe can be understood and its behaviour fully predicted and controlled (Bogg and Geyer, 2007). This mechanistic, 'clockwork' model of science is also a reductionist one, in which it is held that the universe can be understood by investigating the working of smaller sections and adding them together to understand the whole. Complexity theory accepts that this model of

science is both successful and useful – but for understanding closed systems that are local regions of stable reality (Toffler, 1984). It does, however, argue that it is insufficient, because this mechanistic paradigm is unable to explain ‘emergence’, self-organisation, unpredictable change in dynamic systems, and the idea that ‘the whole is more than the sum of its parts’. In a complex system, the interactions and relationship within the system (and between the system and its environment) are crucial to the working of the system, so it cannot be understood by taking it apart and analyzing each section. As Cilliers argues, this analytical method ‘destroys what it seeks to understand’ (Cilliers, 1998 p. 2). In complexity theory, the clockwork model of the universe is replaced with a model that is more organic in nature, reflecting that complex systems are often living systems (Holland, 1998, Davis et al., 2007).

As well as being holistic rather than reductionist, a key feature of complexity is the break with the determinism of traditional (Cartesian or Newtonian) science. This determinism was rooted in the understanding that the laws governing the universe are immutable and that there is a linear link between cause and effect. Complexity theories undermine this link between cause and effect because of the particular non-linear nature of complex systems that allow *emergence* to occur. However, different branches of complexity deal with this issue in different ways. One key distinction is between ‘chaos’ and ‘complexity’ theories. Both of these theories are interested in dynamic systems that change over time, but in Chaos theory, the growth of these systems is determined by particular kinds of non-linear mathematical laws governing their behaviour; a classic example being $Z_{n+1} = Z_n^2 + C$, the defining equation of the Mandelbrot set. Such systems are deterministic because although the behaviour of the system may appear to be random and unpredictable, they are fully determined by a mathematical equation. So in chaos theory, surprisingly simple non-linear models can lead to complex system behaviour, one characteristic of which is that very small changes in the initial conditions can lead to vastly different outcomes. A common example is the ‘butterfly effect’, where a butterfly flapping its wings in the Amazon can alter the path of a tornado in the USA. This suggests that although chaos is deterministic, scientists will never be able to collect enough information about the system and its initial conditions to be able to make predictions of the resultant complex behaviour (Warren et al., 1998). The non-

linearity of chaos theory represents a change from the linear approach to cause and effect which dominated Cartesian thought, but it remains, in principle, a deterministic science.

Complexity theory differs from chaos theory in that, rather than being determined by a constant mathematical formula, the system *self-organises*. As Warren puts it, complex systems are 'constantly changing because non-linear processes tend to build on themselves and cause change from within' (Warren et al., 1998 p. 365). Such systems are often labelled *complex adaptive systems* because the 'rules governing the system can be volatile, subject to change if the system changes' (Davis and Sumara, 2006 p. 11). This volatility arises because the 'components' of the system interact in ways that are not fixed, but can co-adapt and evolve, and because these components are themselves dynamic and adaptive. This perception that complex systems are self-organising and adaptive mean that they are not wholly determined by fundamental laws in the same way as classical physics or chaos theory. This research makes use of complexity theory, rather than deterministic chaos theory and considers a school engaged in curriculum change as this type of complex adaptive system. However, even if the focus is held to be on adaptive complex systems, there remains a range of possible approaches in thinking about complexity which inform the perspective of this research. These will be discussed in greater depth in Chapters 2 and 3. In the rest of this brief introduction to complexity I provide a sketch of the characteristics of complex adaptive systems and then summarise the main differences in approaches to research in complexity, sufficient to inform the complexity-based critical analysis of the research context which constitutes the remainder of this chapter.

Although it is difficult to precisely define complex systems, some characteristics have been offered by writers such as Cilliers (1998) and Davis and Sumara (2006) (See Box 1). The question of whether classrooms, schools and other educational organisations can be appropriately considered to be complex adaptive systems is an important one and such applications of complexity have been critiqued. This question will be considered in Chapter 2, where the literature relating complexity to education is reviewed.

A complex system is likely to have a **large number of elements** that **interact dynamically**. These interactions are **rich** (each element interacts with a number of others) are **short-range** (occur locally, with near neighbours), and have **non-linear** cause-effect relationships. Interactions result in **feedback loops** in the system as it responds to changes in its environment, to which it is **open**. The complex system can **organise itself** and determines its own response to the emergent conditions, rather than responses being determined by its' context. The organisation of the complex system is **nested**, with different emergent levels of organisation which all exhibit elements of complexity as **scale-free networks** (i.e. the rich interactions occur at different levels in a web that may appear similar at different levels). The elements that make up the system are **diverse**, but there are some elements that have similarities (**redundancy**). **Control of the system is distributed** within the system rather than being held by one element. The elements in the system are able to **respond 'randomly' to changes** but there is also **coherence** in the response – environmental/systemic **constraints may enable emergence** as a result of element's responses to these changes.

Box 1: Characteristics of complex adaptive systems, drawing on Cilliers (1998) and Davis and Sumara (2006).

A useful way of thinking about different ways of working with complex adaptive systems was suggested by Richardson and Cilliers (2001) in their introduction to a special issue of *Emergence* which asks, 'what is complexity science?'. They offer a valuable way forward by discussing three 'themes or communities' that characterise research in complexity, whilst recognising that the three categories do overlap and intertwine. These are reductionist complexity science, soft complexity, and complexity thinking. The distinctions that Richardson and Cilliers draw in relation to these three are related to ways of thinking about science and scientific knowledge as well as complexity. Reductionist complexity science, or the 'hard' approach is most closely associated with the natural and physical sciences. This approach 'seeks to uncover the general principles of complex systems' (Richardson and Cilliers, 2001 p. 5) and is associated with the modelling of complex systems undertaken in a range of disciplines. Perhaps the most dominant example of this approach to complexity is related to the work of the influential Santa Fe institute (see, for example, Capra, 1996). It

can be argued that modelling of complex systems must always involve a reduction in complexity, thus setting limits around the knowledge that can be gained from such models. However, scientists working with complexity in this way argue that models such as these may allow us to create a heuristic for experimentation and action through an iterative approach to modelling complex systems in which 'models can provide coarse-grained prediction, be used as a scaffold for our emerging understanding of the data, identify gaps in our...knowledge, and, if the models are good, predict new behaviours that we can explore experimentally' (Finkelstein et al., 2004 p. 27). The reductionist complexity approach has been the subject of critique (Oreskes et al., 1994, Richardson et al., 2001), but remains a dominant model for complexity science.

At the other end of the spectrum is the 'soft' complexity approach. Here, ideas and language from complexity are seen as metaphors that can be used to think about complex systems in the social science (e.g. Byrne, 1998). In part, this distinction reflects differences in kind between natural and social science, and in particular the important role of language and culture in social science. Such 'soft complexity' has tended to be the dominant approach to using complexity ideas within educational research (Doll Jr, 1993b, Davis et al., 2000). Again, this approach has been subject to critique as pseudo-scientific and non-rigorous (Phelan, 2001), mirroring critiques of postmodernist thinking with which complexity theory has been aligned in these fields. Phelan (2004), drawing on Wittgenstein, argues that using the 'language game' of complexity science has great potential, but care must be taken not to use new language in the same way, and to do the same things, as the language game of rationality that preceded it.

The final 'school of thought' referred to by Richardson and Cilliers is 'complexity thinking'. They view this as 'something in between' hard and soft complexity approaches (Richardson and Cilliers, 2001 p. 5), but this is rather humble language for what is effectively an argument for a change in epistemology compared with either the 'hard' or 'soft' communities. Complexity research which focuses more on the reflexive and epistemological dimensions of complexity has been more prevalent in the Latin countries than in work done in the English-speaking field (Alhadeff-Jones, 2008). In particular the work of Edgar Morin examines complex epistemology and advocates a stance in which,

'complex thought involves the integration of both the complexity of our identity as human beings (Morin, 2001) and the complexity of ethical issues generated by a conception of science understood through its own uncertainty (Morin, 1973, 2004). (Alhadeff-Jones, 2008 p. 76)

'Complexity thinking' as an epistemological stance has been developed in Deborah Osberg's work with Paul Cilliers and Gert Biesta (Osberg et al., 2008, Osberg and Biesta, 2007, Osberg, 2005b, Cilliers, 2005), and my research attempts to take their theoretical work forward in an empirical setting. Focusing on the concept of *strong emergence*, these authors draw on the work of Prigogine and the 'Brussels School' to take seriously the implications of complexity in relation to incompressibility, non-linearity and uncertainty, and time-irreversibility. Fundamentally, this leads to a form of complexity thinking that is 'sensitive to [complexity's] own conclusions...that helps us think about the world and knowledge in a way that does not result in, or seek closure' (Osberg, 2005a p. 185). The implications of a 'complexity thinking' epistemology for the theoretical framework of this research requires a more in depth discussion than can be provided in this introduction, and it is taken up once more in Chapters 2 and 3, where I review the literature in relation to complexity and education and develop the theoretical framework for this piece of work.

In this thesis, I attempt to adopt a 'complexity thinking' stance to explore an example of curriculum change. I use the term 'attempt' in recognition of the challenge of developing 'complexity habits of thought' (Kuhn, 2008 p. 186). Kuhn argues that it is insufficient to become familiar with the language and metaphors of complexity, to conduct complexity-informed educational research. Instead, it is necessary to work hard to learn new ways of complexity thinking and resist the 'linear styles of thinking' of the 'predominant western paradigm' in which many of us have been immersed. This resonates with the argument for a complex epistemology put forward by Osberg, Biesta and Cilliers, but is something that has remained a challenge throughout this work.

1.3 Changing curriculum context

This research is concerned with exploring teachers' experiences of an example of curriculum change using a complexity theoretical lens. To explore curriculum change, it is first necessary to explain what is meant by 'curriculum' and how this notion relates to policy and practice in the UK. In particular, the relationship between curriculum and educational reform, relating to the perceived purpose of education, must be considered. After sketching

out this broader picture, I outline the way in which the UK secondary school curriculum has undergone change in relation to 'learning to learn' and science education, providing contextual information for the case study on which this thesis is based.

The term 'curriculum' is used on a day-to-day basis by numerous teachers, teacher educators and others involved in education. For many, it is an unproblematic term, essentially meaning the set of content and skills the students should learn during their education. A brief excursion into literature around curriculum reveals that defining curriculum is as problematic as defining complexity was seen to be earlier in this chapter. Marsh, citing Portelli (1987) notes that 'more than 120 definitions of the term appear in the professional literature devoted to curriculum' (Marsh, 2004 p. 3) and also turns to characterisations of curriculum rather than definition. He cites Walker's (1990) fundamental concepts of curriculum (content, process and organisation), Beane *et al.*'s (1986) principles of curriculum (concern with the experiences of learner, making decisions about both content and process, making decisions about a variety of issues and topics, involving many groups, decision making at many levels), Longstreet and Shane's (1993) conceptions of curriculum (society orientated, student-centred, knowledge-centred, eclectic) and Eisner and Vallance's (1974) orientations of curriculum (cognitive-process orientation, technological orientation, social-reconstructionist orientation and academic orientation) as a range of ways of characterising the curriculum (Marsh, 2004 p. 4). It is clear that values and beliefs are factors which are strongly influential.

The curriculum therefore reflects a range of aspects and judgements over what is important for students to know, or be able to do, and how those aims should be achieved. Doyle argues that curriculum-making occurs at three levels: 'the *institutional level* (the public policy nexus of schooling, learners, culture and society), the *programmatic level* (the syllabus construction of school subjects of courses of study for classroom use), and the *classroom level* (teachers' and students' mediation of curriculum, field, or disciplinary knowledge)' (Connelly, 2008 p. 67), and judgements about curriculum are made at all these levels to create the experienced curriculum.

From the above, we can see that curriculum, and education, is concerned with *purpose*. It is this concern with purpose that makes the language of education distinct from the language

of learning (Biesta, 2009b, Biesta, 2005), and that it is this purpose that makes education a political act. The purposes of education are enshrined within the curriculum, which is also a 'system of reason' – a form of rules and standards that are culturally and historically produced (Popkewitz, 2009). Popkewitz identified the 'reason' of schooling as '[embodying] a style of comparative thought that differentiates, distinguishes and divides' and that as a result, the 'political [nature] of schooling lies...in the shaping and fashioning of what is (im)possible' (Popkewitz, 2009 p. 303). The political nature of the curriculum is therefore shaped by decisions about *what* the curriculum is for and *who* it is for. The politics of curriculum and curriculum change is also therefore influenced by the question of *who decides* what the purpose of the curriculum is and who it is for. Biesta identifies three separate functions of schooling: qualification, socialisation and subjectification, with the activities undertaken in school (the curriculum) designed to meet these different functions (Biesta, 2009a).

Curriculum is often understood as 'top down' in nature: imposed by politicians and 'experts' on schools (teachers and pupils), and also by teachers on pupils (Priestley, 2011). Such an understanding of curriculum can be viewed as the 'planned curriculum'. A model of curriculum 'delivery' or 'implementation' relies on a deficit model of education which identifies knowledge and skills that the pupils are lacking, and designs a sensible progressive order to teach the knowledge or skills to the pupils in a straightforward and linear fashion. This model of curriculum is encapsulated in the influential 'Tyler Rationale', as outlined by Ralph Tyler in his book *Basic Principles of Curriculum and Instruction* (Tyler, 1949). Tyler's rationale asks four questions which, he argues, need to be answered in developing any curriculum:

1. *What educational purposes should the school seek to attain?*
2. *What educational experiences can be provided that are likely to attain these purposes?*
3. *How can these educational experiences be effectively organised?*
4. *How can we determine whether these purposes are being attained?*

(Tyler, 1949 p. 1)

The logic underlying this model of curriculum is intrinsically linear and mechanistic in nature, and remains the dominant mode for understanding curriculum in particular and education more generally. As Doll notes,

Dewey pointed out such a view assumes the learner to be a receiver, not a creator, of knowledge, a spectator who in the most creative of moments can only discover that which already is. A curriculum based on these assumptions emphasizes transmission, linearity, and measurement rather than transformation, nonlinearity, and creation. (Doll Jr, 1993a)

However, complexity theory offers an alternative curriculum model (Doll, 1986) that could be characterised as ‘organic’ (Fullan, 1993) or ‘organocentric’ (Fleener, 2002). Often associated with postmodern and poststructural ways of rethinking curriculum, complexity theorisation of curriculum moves away from the linear, determined curriculum and its associated transmissive models of learning¹ and provides an argument for curriculum as a ‘social meaning system’ which evolves and adapts – *changes* – in relation to its environment (Fleener, 2002). The concept of a curriculum that is mediated and adapted by the teachers and students who are working with it is not new: it resonates with Aoki’s concept of the ‘curriculum-as-lived’ (Pinar and Irwin, 2005) and with the concept of the ‘hidden curriculum’, which describes the learning that takes place in school that is not part of the formal curriculum (Jackson, 1990, Portelli, 1993). However, as well as providing a theoretical grounding for such an understanding of curriculum, a complex epistemology and the concept of emergence allows a view of curriculum that maintains the position of education as distinct from learning on the one hand, and a top-down, mechanistic approach to curriculum on the other (Osberg and Biesta, 2008). This argument and its implications for curriculum change are explained and explored in more detail in Chapter 2.

As I have signalled in the preceding discussion, the model of curriculum encapsulated in the Tyler rationale, linked to a Cartesian mode of thinking, has remained dominant for many years. It is interesting that despite this constancy, there is also a sense that curriculum is constantly changing as changes in education policy lead to regular reviews, revisions and wholesale re-writing of national curricula, exam specifications, and other ‘guidance’

¹ It can be argued that the determinist, linear logic of the modernist curriculum, encapsulated in the Tyler rationale, suggests a logical commitment to a transmissive, deficit model of learning (Doll 1993). It is interesting that many theories of learning attempt to interrupt this transmissive model, such as constructivism, but have not impacted on the overall logic of a determinist curriculum. One of the strengths of complexity theory in relation to education lies in the way it links emergent phenomena at different system levels (Davis 2006), thus explicitly linking a complex understanding of learning to a complex approach to curriculum-making. However, in taking this step it is important to remember, as Biesta reminds us, that education and learning are not the same and should not be conflated. This thesis does not focus on issues of complexity in relation to learning theory except where necessary in the later discussion. For a discussion of complexity in relation to learning theories, see DAVIS, B. & SUMARA, D. J. (1997) *Cognition, Complexity, and Teacher Education. Harvard Educational Review.*

provided for teachers. As Priestley puts it, 'educational change is a fact of life for teachers across the world, as schools are subjected to constant and ubiquitous pressures to innovate. And, yet, many school practices remain remarkably persistent in the face of such innovation.' (Priestley, 2011 p. 1). In this thesis, I argue that this persistence is in part due to the dominance of mechanistic approaches to education, and that complexity thinking may offer teachers a different way forward in working with curriculum change and innovation. In the following and final parts of this introduction to the thesis, I outline recent policy-driven curriculum change in education in the UK. I begin with a general introduction to curriculum change preceding and during the period of research, before discussing two areas of curriculum of particular relevance to this case study: learning to learn and science education.

1.3.1 Education and curriculum policy in the UK

The way in which curriculum has been developed in the post-war period in the UK has undergone a radical shift, with a reduction in the extent to which teachers formally control both curriculum content and pedagogy: there has been a moving away from the idea of 'teacher knows best' towards a model in which the teacher 'delivers' a curriculum prescribed by the state, ideally using methods sanctioned as 'best practice'. In the decades following the second world war, political debate tended to focus on the structures of schooling, leaving decisions over content and pedagogy to the teachers (Lowe, 2007). In terms of curriculum organisation, the 1960s and 1970s saw an increase in 'progressive' education and curriculum integration, with the Plowden report an influential factor in organisation of the primary curriculum (Carr, 2007). Without a prescribed curriculum, teachers and schools had more power and influence in determining the organisation and content of learning experiences for the students in schools, with the examinations guiding the expectations of content at secondary level, but otherwise a great amount of freedom. For example, 'Mode 3 Certificate of Secondary Education' exams had course content and examination determined by teachers with external moderation for quality assurance. However, during the late 1970s and into the 1980s there was a division between those who argued for a more traditional curriculum, with the 'Black Papers' expressing the concerns of the political right-wing, arguing against comprehensive education and progressive teaching methods (Gillard, 2011). These ideas were taken up by Margaret Thatcher's government,

who gradually began to exert greater centralised controls over what went on in classrooms as well as the wider school structures, with a reduction in the role of the local authority and changes to the funding systems ensuring a mechanism of control. Lowe summarises the trend, reflecting on, ‘the enormous freedom which the schools had during the period (60s-70s) to experiment with whatever curricular variant was thought most appropriate to the needs of the students in that particular school. It was a freedom which stands in stark contrast to the more recent impositions on the power of schools to plough their own furrow’ (Lowe, 2007 p. 52). In the following sections, I examine in more detail the changing culture of education and impact on the teachers’ role before considering the new curriculum and the potential for further changes in the way in which teachers relate to the curriculum.

1.3.2 Influences on the culture of education in the UK

In 1989, the first national curriculum for England and Wales was introduced as a means of central regulation². In this curriculum, detailed programmes of study and attainment targets were outlined for a wide range of subjects, and there was a related increase in the amount of planning control and paperwork teachers were expected to produce (Hacker and Rowe, 1998). Increased accountability was introduced as part of the same political direction, with changes made to the school inspectorate. Her Majesty’s Inspectorate (HMI) was changed to the Office for Standards in Education (Ofsted) with an associated shift in the inspector’s role from adviser to judge. This was followed by the introduction of national tests (colloquially known as SATS) at ages 7, 11 and 14 and the publication of league tables of school performance.

Moore and Young (2001) discuss two dominant views of curriculum in recent curriculum policy: neo-conservative traditionalism and technical-instrumentalism. Characteristics of these two discourses are summarised in Table 1. Both these discourses lie within the mechanistic, Cartesian logic described in the preceding discussion of curriculum. With a change of government from Conservative to Labour in 1997, one might have anticipated a reversal of some of these political drivers in educational reform. However, Blair’s

² Education policy in the United Kingdom is devolved, so the ‘national curriculum’ to which I refer in this work applies to England and Wales and not to Scotland or Northern Ireland.

‘education, education, education’ rallying cry brought with it the introduction of various national strategies and frameworks which advocated a range of ‘best practice’ pedagogies.

Table 1: Discourses of curriculum policy (Moore and Young 2001)

Neo-conservative traditionalism	Technical-instrumentalism
<ul style="list-style-type: none"> □ Curriculum is a body of knowledge for schools to transmit □ Schooling should engender respect for ‘canonical texts’ □ Experience of submitting to the discipline of a subject and becoming the kind of person it makes you is important. 	<ul style="list-style-type: none"> □ ‘Industrial trainers’ □ Curriculum should support the needs of the economy □ Education and knowledge is a means to an end and not an end in itself □ More recently, the focus has been on preparation for a ‘knowledge society’, with the emphasis on training to take part in that society rather than education as a ‘maker of persons’. p. 447

Beginning with the national literacy and numeracy strategies (Fullan, 2003), these went on to incorporate behaviour, assessment, inclusion and school leadership (DfE, 1997-2010) and constitute a continuation of the culture of performance and accountability begun in the 1980s (Glennerster, 2001, Barber, 2001). During Labour’s period in power, there have been revisions to the curriculum (QCA, 2004, QCA, 1999) in which the national curriculum has undergone changes designed to reflect more closely the needs of society. In some ways, this denotes a shift from Moore and Young’s (2001) neo-conservative traditionalism towards technical-instrumentalism. Government documentation and reports on education policy and curriculum (Tomlinson, 2004, Millar and Osborne, 1998, Dearing, 1997) could be seen as promoting an instrumental view of education, where each subject has to a certain extent to argue for its place in the curriculum based on what it can offer children in terms of skills for the future society. In relation to the question of what these skills might be, questions such as those raised by Sir Ken Robinson (2006) suggest that given the rapid pace of change and the internet revolution, it could be argued that we do not even know what the students we are teaching will need in terms of knowledge and skills: what, then, should the curriculum be educating for? Leat (1999), and many others (e.g. Claxton, 2002, Burden and Nichols, 2000) point to education for thinking skills, and programmes such as ‘Learning to Learn’ (L2L) are often put forward in schools. To a certain extent, these ideas have been

incorporated into the curriculum revision with which this research is most concerned in the form of PLTS (Personal, Learning and Thinking Skills) which are designed to be covered through each of the 'subjects' (QCA, 2007a). The discourse of 'Learning to Learn' and its relationship to the traditional subject-based curriculum are explored next.

1.3.3 'Learning to Learn'

Learning to Learn (L2L) has become increasingly prevalent in UK schools, reflecting a shift in education policy which emphasizes one important aim of schooling to be 'learning how to learn in preparation for a lifetime of change' (D. Miliband, 2003). The current UK coalition government cites one purpose of the national curriculum to be to, 'instil in children a positive disposition towards learning and a commitment to learn' (DfE, 2011). In the UK context, this engagement with the L2L agenda has been demonstrated in the funding of large-scale research projects (E.g. TLRP, 2001-2006), seminar series (Moseley et al., 2005), working groups (DEMOS, 2005) and the incorporation of whole-school programmes such as Building Learning Power (Claxton, 2002) in numerous schools across the country. It is widely held by teachers involved in such work that L2L also has the potential to improve standards, though the evidence for this is not always clear (Higgins et al., 2006). This move within the UK mirrors a wider, international interest in Learning to Learn and lifelong learning skills, with bodies such as the European Commission and UNESCO interested in work to define and assess learning skills and competencies (Hoskins and Fredriksson, 2008).

Despite such widespread interest in L2L, the concept of what constitutes learning to learn and the most effective pedagogy for promoting it remains problematic. L2L can be thought of as an umbrella notion which may incorporate related ideas such as metacognition, self-regulated learning, learning how to learn, thinking skills and learning dispositions (Hall et al., 2006). Black et al. (2006) describe learning to learn as 'slippery and contested...with many subtly different meanings' (Black et al., 2006 p. 120). Broadly, L2L ideas incorporate two dominant discourses, drawing on cognitive psychological and sociocultural understandings of learning, with some differences in pedagogical approach and forms of assessment differing in emphasis depending on underlying conceptualizations of learning. James et al. (2006) offer a useful summary of the influence of three broad schools of learning theory (behaviourism, constructivism and sociocultural theories) and the influence of these on the

sorts of questions that can be asked in relation to learning to learn. I provide a necessarily brief summary of these learning theories and implications for L2L in Table 2.

Table 2: Learning theories in relation to 'learning to learn'.

Learning Theory	Brief outline of the learning theory	Implications for Learning to Learn
Behaviourism (E.g. Skinner, 1953/2005)	Learning is conditioned response to stimulus. Rewards and sanctions are means to establish desired behaviour. Complex skills and knowledge can be taught by breaking it down into smaller pieces and teaching the basics first.	Learning to learn is not separate from learning generally – new learning of any kind is an automatic response to stimulus. L2L practitioners have broken down 'learning skills' into aspects in which pupils can be 'trained'.
Cognitive Constructivism (E.g. Geelan, 1997, von Glaserfeld, 1995)	Learning entails the learner analysing and transforming new information in relation to their pre-existing 'mental models' or schema.	Implies that learners need to be able to monitor their own learning and determine for themselves whether they understand. This model of learning is related to metacognition, reflection and self-regulation in the L2L literature. L2L is seen as a higher or second order form of learning, where content-based learning is 'first-order'.
Social Constructivism (E.g. Vygotsky, 1978)	Linked to cognitive constructivism, this extends the notion of cognitive constructivism and argues that learning happens in interaction with a 'more able other' and is mediated by language and other learning tools. Teachers 'scaffold' the pupils in their construction of knowledge and have a responsibility for maintaining pupils learning with a 'zone of proximal development'.	Implications are the same as for cognitive constructivism, with the additional implication of the role of the teacher in scaffolding pupils' development of metacognitive strategies and learning skills.
Sociocultural Theory (E.g. Leach and Scott, 2003, Lave and Wenger, 1991)	Knowledge is distributed within a community and is cultural in nature. Learning takes place within 'communities of practice' in which learners are seen as apprentices who learn from those within the community who are more expert, so learners acquire knowledge, skills <i>and values</i> about what is important. Learners use tools (such as language) to construct their environments and knowledge, and because tools are social and cultural practices, they embody the history of that community of practice and form part of the distributed knowledge community which learners learn to participate in. Learning involves collaborative problem-solving.	Sociocultural theories of learning suggest that learning to learn in schools would involve using tools, such as language, to initiate students into 'cultures of learning' and build learning environments in which L2L is recognised as good learning. This has been taken up to some extent, with whole-school approaches adopted involving use of particular language, tools, resources (including time) and values to support learning to learn.

Complexity theory can be related to the dominant learning theories above, particularly constructivist and sociocultural theories, depending on the level of analysis of the complex system of schooling and education on which one is focussing (McMurtry, 2006). These relationships have been considered elsewhere (Doll Jr, 2008, Proulx, 2008, Smitherman Pratt, 2008b, Davis and Sumara, 1997). Although it is possible to relate ideas about learning drawn from complexity theory to dominant theories of learning within educational discourse, the distinctive element of a complexity approach is where complexity thinking is used as an epistemological basis in which emergence is key, and which runs counter to mechanistic, Cartesian frameworks. Sociocultural theory is perhaps the framework which is closest to complexity, but instead of focussing on induction into and evolution of existing cultural practices, complexity focuses on the unpredictable learning which may emerge from the 'community of practice' when it is in a state of disequilibrium. In this thesis, I am concerned with what happens within such a 'community of practice' when the curriculum is changed and the system is therefore no longer in an equilibrium state.

The particular case explored here was that of a school involved in the introduction of a curriculum designed to develop 'skills for the 21st century', including learning to learn. The school took the decision to base their new curriculum on the Opening Minds (OM) curriculum run by the Royal Society of Arts (RSA), which is a competency-based curriculum designed to develop skills 'to equip young people for the 21st Century'. The RSA's OM curriculum is designed to be flexible and context dependent, so teachers 'design and develop the curriculum for their own schools based round the development of five key competencies' (RSA, 2008-2012). Since its development, OM has been adopted by over 200 schools across the UK, and represents one major curriculum development related to the changing policy contexts described in this introduction. A case study into a school developing a curriculum based on OM was chosen because OM explicitly encourages flexibility for the school rather than a wholesale adoption of a pre-existing L2L programme. OM can therefore be introduced as an additional element within a subject-based curriculum, or it can be taught separately. The relationship between learning to learn approaches and the traditional subject structure of the majority of UK (and international) schools has not always been clearly articulated in the introduction of L2L approaches in school. L2L is often viewed as something that is relevant to, and can be developed in, all

subject areas (Claxton, 2002). In the 2007 curriculum revision that is the subject of this research, a number of 'cross-curricular dimensions' were identified as part of the 'Big Picture' of the curriculum. Learning skills were found in the 'personal, learning and thinking skills' aspect of the curriculum which cut across all subject areas, and within the cross-curricular dimensions in the 'creativity and critical thinking' strand (see Figure 1).

A big picture of the secondary curriculum

The three questions:

1
What
are we trying
to achieve?

Statutory curriculum aims Every child matters outcomes Focus for learning	Successful learners who enjoy learning, make progress and achieve	Confident individuals who are able to lead safe, healthy and fulfilling lives	Responsible citizens who make a positive contribution to society
Be healthy	Enjoy and achieve	Make a positive contribution	Achieve economic well-being
Attitudes and attributes eg determined, adaptable, confident, risk-taking, enterprising	Stay safe	Skills eg personal, learning and thinking skills	Knowledge and understanding eg big ideas that shape the world

2
How
do we
organise
learning?

The curriculum as the entire planned learning experience underpinned by a broad set of common values and purposes

Environment	Events	Extended hours	Learning outside the classroom	Lessons	Locations	Routine									
Valid and matched to learning need eg enquiry, instruction, active, practical and theoretical	Assessment is fit for purpose and integral to learning and teaching	Opportunities for spiritual, moral, social, cultural, emotional, intellectual and physical development	In tune with human development	Assessment develops learners' self-esteem and commitment to their learning	Personalised - offering challenge and support to enable all learners to make progress and achieve	Relevant, purposeful and for a range of audiences	Assessment uses a wide range of evidence to encourage learners to reflect on their own learning								
Approaches to learning	Overarching themes that have a significance for individuals and society, and provide relevant learning contexts: Identity and cultural diversity – Healthy lifestyles – Community participation – Enterprise – Global dimension and sustainable development – Technology	Art & design	citizenship	design & technology	English	geography	history	ICT	mathematics	MFL	music	physical education	PSHE education	religious education	science

3
How well
are we
achieving
our aims?

To make learning and teaching more effective so that learners understand quality and how to improve

Evaluating impact	Looks at the whole child eg curriculum aims, progress in skills, subjects and dimensions	Uses information intelligently to identify trends and clear goals for improvement	Using 'critical friends' to offer insights and challenges	Uses a wide range of measures both qualitative and quantitative	Creates a continuous improvement cycle	Uses a variety of techniques to collect and analyse information	Involves the whole school community eg learners, parents, teachers, employers, governors
Accountability measures	Attainment and improved standards	Behaviour and attendance	Civic participation	Healthy lifestyles	Further involvement in education, employment or training		

Despite the increasing attention being paid to cross-curricular aspects, this curriculum still maintained an important role for the traditional subject.

The new curriculum builds on the best of the past by maintaining subject disciplines but at the same time providing greater opportunities for personalised learning, addressing the major challenges that face society and equipping young with skills for life and work in the 21st century. (QCA, 2007d)

The actual relationship within schools between the ‘learning to learn’ and ‘21st century skills’ elements of the new curriculum and the traditional school subjects was left to the schools themselves to determine flexibly in relation to their particular context (QCA, 2007c). Similarly, the new curriculum specified less content detail in each subject area of the national curriculum, shifting the balance between ‘content’ and ‘process’. In this research, the relationship between the L2L aspects of the curriculum and the traditional school subjects was explored in relation to school science. In the final part of this introduction, I turn to the science curriculum and outline the position of science in relation to curriculum, policy and practice.

1.3.4 ‘How Science Works’

In England, as elsewhere, science currently holds a relatively privileged position in the secondary school curriculum as a statutory subject that still maintains a relatively high percentage of curriculum time, as indicated by the requirement that schools offer students the opportunity to study at least two GCSEs in science subjects (though pupils may choose to take single, double or triple science) (DCFS, 2009). This was not always the case; but the move towards the introduction of a ‘broad and balanced’ national curriculum included strong arguments made for the provision of a minimum requirement to study science, along with English and mathematics, as ‘core subjects’ (Dodd and Shaw, 1990, Black, 1995). During the 20th Century, science in the school curriculum had come to be dominated by physics, biology and chemistry as separate subjects, with science ‘elbowing out classics from the leading status position. Physics had come to be seen as the highest cachet in the spectrum’ (Dodd and Shaw, 1990 p. 34). This de facto separation has remained, despite the national curriculum and GCSE exam specifications avoiding using the science disciplines as subject labels (see Table 3 for a summary of the current³ Key Stage 3⁴ secondary science

³ The national curriculum is again under review, with changes likely to be implemented in September 2014.

curriculum). This is also reflected in the training of science teachers: although it is possible to train to teach general science, and all science teachers are expected to be able to teach science subjects across the board to at least age 14, most science teachers are ‘specialists’ in one of the three main natural science disciplines.

Table 3: Summary of the KS3 national curriculum for science

‘Key Concepts’

Scientific thinking

- a. Using scientific ideas and models to explain phenomena and developing them creatively to generate and test theories.
- b. Critically analysing and evaluating evidence from observations and experiments.

Applications and implications of science

- a. Exploring how the creative application of scientific ideas can bring about technological developments and consequent changes in the way people think and behave.
- b. Examining the ethical and moral implications of using and applying science.

Cultural understanding

- a. Recognising that modern science has its roots in many different societies and cultures, and draws on a variety of valid approaches to scientific practice.

Collaboration

- a. Sharing developments and common understanding across disciplines and boundaries.

‘Key Processes’

Practical and enquiry skills

- Pupils should be able to:
- a. use a range of scientific methods and techniques to develop and test ideas and explanations
 - b. assess risk and work safely in the laboratory, field and workplace
 - c. plan and carry out practical and investigative activities, both individually and in groups.

Critical understanding of evidence

- Pupils should be able to:
- a. obtain, record and analyse data from a wide range of primary and secondary sources, including ICT sources, and use their findings to provide evidence for scientific explanations
 - b. evaluate scientific evidence and working methods.

Communication

- Pupils should be able to:
- a. use appropriate methods, including ICT, to communicate scientific information and contribute to presentations and discussions about scientific issues.

‘Range and Content’

Energy, electricity and forces

- a. energy can be transferred usefully, stored, or dissipated, but cannot be created or destroyed
- b. forces are interactions between objects and can affect their shape and motion
- c. electric current in circuits can produce a variety of effects.

Chemical and material behaviour

- a. the particle model provides explanations for the different physical properties and behaviour of matter
- b. elements consist of atoms that combine together in chemical reactions to form compounds
- c. elements and compounds show characteristic chemical properties and patterns in their behaviour.

Organisms, behaviour and health

- a. life processes are supported by the organisation of cells into tissues, organs and body systems
- b. the human reproductive cycle includes adolescence, fertilisation and foetal development
- c. conception, growth, development, behaviour and health can be affected by diet, drugs and disease
- d. all living things show variation, can be classified and are interdependent, interacting with each other and their environment
- e. behaviour is influenced by internal and external factors and can be investigated and measured.

The environment, Earth and universe

- a. geological activity is caused by chemical and physical processes
- b. astronomy and space science provide insight into the nature and observed motions of the sun, moon, stars, planets and other celestial bodies
- c. human activity and natural processes can lead to changes in the environment.

⁴ The National Curriculum is separated into five ‘Key Stages’. Key Stage 3 is taught in early secondary school to pupils between the ages of 11-14, in years 7, 8 and, in some cases, 9.

Despite its relatively privileged position, concerns have been expressed as the numbers of students taking science subjects in post-compulsory education has decreased (Osborne et al., 2003b). This trend in the UK is also found in other developed countries (Sjøberg and Schreiner, 2007) and has prompted concern because of the perceived relationship between science education, technology, and economic performance (E.C., 2004, AAAS, 1989). Literature exploring the reasons for pupils' disengagement from science finds numerous contributing factors, including a sense of science as difficult, dry and abstract (Jenkins and Pell, 2006, Osborne and Collins, 2001). The importance of science in the curriculum has been highlighted for two reasons, both of which can be seen as 'technical-instrumental' (see Table 1). These reasons are the preparation of future scientists and the preparation of future citizens (Millar and Osborne, 1998). The need to design a curriculum that includes sufficient basis in the knowledge and skills required for future scientists alongside the development of 'scientific literacy' (to enable students who will not become scientists to engage in democratic debate about scientific issues and make their own assessments of the validity of scientific claims in their future lives) has not been found to be straightforward, but has been influential in the changes to the science curriculum since 2000.

The notion of scientific literacy has been developed in curriculum initiatives in England over the last ten years, with greater emphasis placed on 'How Science Works' within the national curriculum. This has been taken up in the development of various GCSE exam specifications such as that developed by the 21st Century Science project (Ryder and Banner, 2011, 21st Century Science Project team, 2003). Since the focus of this thesis is on Key Stage 3 curriculum change, I do not discuss in any detail the changes to the KS4 curriculum here. Suffice to say, changes introduced to emphasise the 'How Science Works' component of the GCSE examinations at KS4 as a result of changes to the KS4 national curriculum in 2006 (DfES, 2005) influenced the teaching of science at KS3 in similar directions in order to prepare students for the new GCSEs. However, the national curriculum at KS3 was not formally changed until the implementation of the general curriculum changes in September 2008 (QCA, 2007b).

In part, the debate surrounding the position of science in the national curriculum stems from an understanding of why science is important and what it can distinctively contribute to pupils' education (Donnelly, 2006). The issue of the nature of science, which is translated

into the English national curriculum under the umbrella of 'how science works', is of interest in this work because the relationship between science as a traditional subject and the 'learning to learn' aspects of the new curriculum depend on what science is understood to be (and therefore its relationship to learning and 'skills for life'). Reviewing the national curriculum since its inception, Donnelly (2001) identified two conflicting versions of the nature of science in the curriculum documentation: one is empiricist and focuses on the techniques and procedures of scientific method, and the other focuses on the social and cultural influences on science. Both of these can be identified in the current KS3 curriculum under the headings of 'key concepts' and 'key processes' to be taught through the loosely identified 'range and content' (see Table 3). The nature of science as it appears in school curricula, though lacking somewhat in clarity, must be 'at best a simplification...of the full range and subtlety of contemporary thought about the nature of science' (Taber, 2008 p. 181). Until the most recent curriculum revision, the emphasis of the nature of science was clearly rooted in a straightforward understanding of the scientific method as exemplified in the school science 'investigation'. In these investigations, pupils formulate a hypothesis for a given experiment, plan a method, collect and analyse data, and form a conclusion. They are taught about variables and how to formulate a 'fair test' in a system that attempts to model the work of experimental science. However, the questions pupils are asked to investigate are given to them in advance, meaning that they are following a linear pathway towards an answer that the teacher already knows in advance (Gott and Duggan, 1995, Donnelly et al., 1996). Despite the recent changes of emphasis away from a simple model of scientific method, this notion has remained a consistent part of 'how science works' in the curriculum, with the addition of aspects such as the history of science, the communication of science, and the need to develop 'higher order thinking skills' being incorporated into the curriculum and pedagogy in some schools (Toplis et al., 2010).

A further trend in the science curriculum leading up to the period of this research relates to the notion that science can support the development of 'higher order thinking skills'. One initiative that received widespread support and adoption in many schools was the Cognitive Acceleration through Science Education (CASE) programme (Adey et al., 2003). Designed as an intervention program within an existing science curriculum, CASE aims to develop pupils' capabilities in understanding scientific concepts and thinking scientifically through the use

of small activities designed to enable students to reason for themselves and construct their own learning in response to particular problems. I introduce CASE here because it was part of the science curriculum in the case study school, and the notions it promotes, of the development of thinking skills in science, may be one area where the relationship between 'learning to learn' and the science curriculum changes appear to be moving in similar directions.

It is clear from the preceding discussion that the science curriculum in the UK, despite undergoing several changes with resultant shifts in emphasis, has remained relatively stable in terms of the overarching curriculum structure. Whether the content or processes of science are emphasised, a Cartesian framework for the curriculum remains, with the identification of knowledge and skills required of the expert scientist or the scientifically literate citizen identified, and the curriculum designed to facilitate learning in these directions. Interestingly, responses to the disengagement of students with science has led to arguments being put forward for 'inquiry based science education' (IBSE) and 'argumentation' in science, in which pupils' own questioning, discussion and decision-making takes a higher priority than seen hitherto (Osborne et al., 2004, Minner et al., The Fibonacci Project, 2010). These schemes have been found to be effective in improving attitudes to and attainment in science, but involve challenges in the shared participation between teachers and students in the construction of knowledge. It has been argued that 'IBSE offers one way to engage young people in a way that allows them to express their own voices and find themselves recognized and valued within the construction of scientific knowledge.' (Wegerif et al., In preparation for 2012/13). Although challenging, this move in development of the science curriculum has the potential to maintain the direction of change seen in the current national curriculum whilst enabling the development of pedagogy to which complexity thinking can contribute, if the shared construction of knowledge and responsibility of the teacher to challenge students' thinking is taken seriously.

1.4 Rationale for the study

In the above discussion, I have introduced complexity theory as the theoretical perspective informing this thesis. Complexity theory, and in particular 'complexity thinking' affords a new way of looking at educational activity that both draws on, and critiques, existing ways of thinking about education and learning from postmodern or poststructural frames. The

concept of *emergence* in complexity theory and the associated move away from Cartesian logic have particular implications for the study of curriculum and the question of purpose in education. In this chapter, I have briefly introduced a complexity perspective on curriculum, offering arguments that 'curriculum' as it is typically understood is rooted within a mechanistic approach to education, which is undermined if schooling is explored from the perspective of a complex system.

I then introduced the particular curriculum context for this research, discussing the ongoing trends in curriculum change in England, which mirror similar trends elsewhere (in Europe and North America). Two key areas of curriculum change were focussed upon: 'learning to learn' and 'how science works'. In both of these areas, the mechanistic model of curriculum is exemplified in the traditional and instrumental approaches to curriculum embodied within them, either in the form of desired knowledge or skills. However, in the areas of 'learning to learn' and 'how science works', and in the flexibility that was introduced in the new curriculum (QCA, 2007c), a desire to open up education for students can be seen. Alongside the mechanistic understanding of curriculum with the identification of particular, desirable knowledge and skills, a recognition that technology and society are changing too quickly for the curriculum to predict what knowledge or skills will *be* desirable is recognised, with a resultant move towards creativity as an important element of schooling (Claxton, 2006). The desire to open education to students' own questioning, choice and creativity can be seen in some aspects of the learning to learn curriculum changes and in moves within science education such as Inquiry Based Science Education.

This research study therefore aims to explore how these moves within the changing curriculum are experienced and explored by teachers working with a new 'learning to learn' curriculum, using complexity theory as a novel theoretical perspective. A case study was undertaken in which a new curriculum, 'Opening Minds' was introduced into the Year 7 curriculum in one English state school. Opening Minds is a skills-based curriculum run by the Royal Society of Arts and is designed to be interpreted flexibly by the numerous different schools who introduce it. As such, it was felt to be a relevant choice of case study to explore curriculum change using complexity, as the in-built flexibility meant that the direction of change was not significantly constrained by the programme adopted. The details of the OM curriculum will be described in Chapter 5 of this thesis. Suffice to say for now that the

Opening Minds curriculum has the *potential* to challenge the dominant mechanistic framework for education, and this research seeks to use complexity theory to explore the effect of such a challenge in this particular case. The research also aims to explore the relationship between Opening Minds and science as a traditional school subject area, and how the potential challenge to mechanistic education offered by opening minds interacts with science education in this case.

In the next two chapters, I provide a critical analysis of the literature in relation to complexity theory and education and develop a theoretical framework for the thesis. I then make use of this theoretical framework to consider some key aspects of social theory from the perspective of complexity, in particular relating to concepts of agency/structure, identity, power and reflexivity, which are used to explore the case.

Chapter 2 - Developing a Complexity Theoretical Framework

2.1 Introduction

In the previous chapter, I introduced complexity theory as a way of thinking that is an alternative to the reductionist and mechanistic character of classical Western thought. In this chapter, I expand on how the concepts of complexity theory have been taken up in educational theory, research and practice and how this has been critiqued. In particular, I offer an overview of literature relating to the use of 'soft complexity' as a metaphor to understand and transform teaching and learning and the introduction of 'complexity thinking' to rethink education and the role of the teacher. I then build on this literature to create a theoretical framework for this research based on complexity thinking.

The aim of this research is to examine a case study in which a new curriculum with the potential to challenge the Cartesian logic of traditional curricula was enacted, using a theoretical framework rooted in complexity theory. The theoretical framework developed here uses complexity theory in two ways – as both an epistemological frame and an interpretive tool. Using the loose distinctions of schools of thought in complexity theory introduced by Richardson and Cilliers (2001), my conception of complexity theory for this particular research is using both 'complexity thinking' to guide the research in an epistemological sense alongside a 'soft' complexity approach in which the language of complexity as developed in the theoretical framework is used to describe the case and as an interpretive lens in analysing the case. The concept of 'emergence' is key to the framing of complexity theory used in this research, where I conceptualise emergence in both a temporal and a relational sense.

Of particular interest in this research is the relationship between individuals, groups and the curriculum: complexity theory is a theory of relations, interactions and emergence, and in this chapter I show how complexity offers a particular lens through which to view the interactions and relationships of the case. Emergence in complexity theory includes both a temporal aspect *and* a relational aspect. Emergence as a result of self-organisation (in a social context, of social groups in relation to individuals, which are both present at the same moment) will be labelled 'relational emergence'.

I also consider the epistemological implications of the complexity theory framework outlined here in relation to temporality and the break with Cartesian logic offered by the 'logic of emergence' (Osberg and Biesta, 2007 p.7, Osberg and Biesta, 2010). I label emergence in this sense, 'temporal emergence'. Clearly, these two understandings of emergence are intertwined, and may occur in reality separately or at the same moment, with acts of temporal emergence impacting on the relational and vice versa. As Thrift points out, 'Whereas previous bodies of scientific theory were chiefly concerned with temporal progression, complexity theory is equally concerned with space' (Thrift, 1999 p. 32). Given that emergence is used in both senses in the complexity literature, it seems sensible to be clear within this research over the related senses of emergence being used in the analysis.

A third concept within the framework is that of complexity reduction. Schools are highly structured, hierarchical, governed and predictable, whilst at the same time being capable of unpredictability. Complexity reduction involves the reduction of 'options for action' within a system (Biesta, 2010a) in various ways, for example through the action of imposed, rather than emergent structure⁵ At the same time, complexity reduction also enables emergence, as the action of complexity reduction *also* acts to enable new organisation or meaning to be made.

The complexity-based theoretical framework developed therefore includes three interweaving elements:

- relational emergence, which focuses on emergence of and through aspects such as the relationship between individual and group, or agency and structure. This may include both human and non-human elements within the system (for example, the curriculum materials in tandem with the 'lived' curriculum);
- temporal emergence, which is concerned with unpredictability and change, opening new 'impossible possibilities';

⁵ By which I mean the imposed structure has emerged beyond the 'boundaries' of the case, and therefore although it could be considered emergent, it is so at a broader level than that of the case and could therefore be considered as imposing on it. Although the broader structure is affected by the case, the case is only part of the elements that influence the larger-scale emergent structure. The same argument is made within school on a smaller scale.

- complexity reduction, concerned with ways in which emergence is constrained, and also possibly enabled, by a reduction in complexity through the action of imposed structures or limitations on freedom.

Together, these elements develop a lens through which to examine the tensions and possibilities experienced in the emergence and development of a new curriculum in a particular school system. The thesis is therefore concerned with complexity in relation to education, and includes consideration of education from the perspective of emergence and complexity reduction in the context of both the 'Opening Minds' curriculum and in the context of the science curriculum. Throughout this chapter, as I develop the framework, I relate the ideas to education and educational settings: this is not intended to be a complexity theory grand social narrative, but a framework developed for a particular educational research project that is related to and inspired by broader social and complexity theories. As Fenwick argues, 'theories of dynamic phenomena, including complexity theory...are constantly in danger of supplanting an appreciation for the open-ended complexity of living phenomena by collapsing it into a manageable theoretical apparatus' (Fenwick, 2010b p. 65): I hope to maintain an appreciation for open-ended complexity throughout the project, since although there must be some reduction in complexity, the process itself may also contribute to the emergence of new complex understandings (see chapter 4 for further discussion of this argument). However, to create a manageable thesis, I must at the same time focus in, and the framework developed in this chapter is part of this process.

In this chapter I will therefore begin by reviewing the use of ideas from complexity theory in relation to education. I then use insights drawn from this literature to develop and explain the three key elements of the theoretical framework and the way I see these elements as interacting. I will define the ways I am using terminology such as *emergent change* and *mechanistic change* to indicate different ways of thinking about change in the school system, where emergence is open-ended in comparison with the 'ends-based' change for which I use the term 'mechanistic'. The theoretical framework discussed and developed in this chapter is the basis of the research epistemology and is thus used to inform both the methodology and analysis of the case study data in what could be called a 'postmodern'

complex methodology in which research questions and methodology emerge through the process of the research. The research methodology is explored in depth in chapter 4.

2.2 Complexity theory and education

2.2.1 Critiques of complexity theory as applied to education settings

Complexity theory is often cited in the literature as a new paradigm for exploring many aspects of experience, and although it has been argued that complexity has now ‘come of age’ (Davis and Sumara, 2012 p. 30), with many disciplines increasingly taking a ‘complexity turn’ (Urry, 2005), it has taken some time for ideas from complexity theory to be taken up in education settings in comparison with other areas such as economics and organisation studies (Gough, 2012). As I showed in chapter 1, complexity theory is concerned with dynamic systems that are open, relational, non-linear and emergent. In recent decades, educationalists have begun to take these ideas forward in a range of different settings, including in relation to learning in social work (Wolf-Branigin, 2009), dentistry (Townsend et al., 2012), medicine (Cooper et al., 2004) and higher education (Knight, 2001, Haggis, 2004) as well as within the setting of school-based education with which I am concerned in this thesis.

Complexity theory in relation to education has been dominated by the use of complexity metaphors to understand and re-think educational systems (e.g. Namukasa and Simmt, 2003, Doll and Gough, 2002). ‘Hard’ complexity science has been used in social science to model the interactions between individual and social behaviours (e.g. Mubayi et al., 2011, Roca and Helbing, 2011), but has not been strongly taken up in education. This is one area where it is once again important to remember the distinction between ‘learning’ and ‘education’, as the use of hard complexity science in modelling *learning* in various ways is an active area of research, as shown by the Santa Fe Institute’s research area in ‘Emergence and Decision making in Cognitive Systems’ (Santa Fe Institute); but in terms of education and schooling, the modelling approach to complexity has found limited use, with examples limited to modelling of large-scale change in a discourse more closely related to the organisational management literature (e.g. Maroulis et al.). Before considering the different ways in which complexity theory has been used in relation to education, it is worth first examining the debate over whether or not it is reasonable to use complexity theory to study students, classes and schools. The question over whether it is acceptable to ‘apply’

complexity theory principles to schools has been raised in critiques of the use of complexity in relation to education. These critiques have questioned complexity in relation to education in at least three ways: a) whether schools are indeed complex systems, b) whether complexity theory adds anything new to the debate that is not already well-covered in other theoretical frames without the need to invoke a 'new kind of science', and c) whether it is reasonable to apply ideas drawn from the natural sciences to social science, given the differences between thoughtful human action and the inanimate action of the physical world.

The question of whether the use of complexity theory to understand education is a valid approach rather depends on *how* complexity is being used. One regular strategy in the literature on the subject of complexity and education is to identify characteristics of complex systems and suggest that schools meet these characteristics. For example, Radford cites Cilliers' ten characteristics of complex systems before going on to state that, 'It is not difficult to make a case for the relevance of all these characteristics in the school system in general and to individual schools' (Radford, 2006 p. 183), although he does not explicitly make that case himself. Davis and Sumara employ a similar (though more elaborated and nuanced) argument in their book *Complexity and Education*, where they discuss the 'qualities' of complex systems before considering how they can be applied to a range of educational phenomena (Davis and Sumara, 2006). However, much of the work done in relating complexity theory to education takes it as read that educational systems are complex. In relating complexity to education, it appears that the cases that are most regularly made are for treating individual learners as complex (the brain as a neural network is one of the most commonly cited examples of emergence) (Mitchell, 2009), or treating whole-school change or educational policy as complex (Fullan, 2003, Morrison, 2003). For example, Morrison argues the case for treating schools as complex:

Schools exhibit many features of complex adaptive systems, being dynamical and unpredictable, non-linear organizations operating in unpredictable and changing external environments. They maintain 'relative autonomy' from the wider society and position themselves to maximum effect and decide where they wish to be in relation to it (finding their niche, identity and autopoiesis). Indeed, schools both shape and adapt to macro-societal and micro-societal change, organizing themselves (perhaps in response to external constraints and pressures), responding to and shaping their communities and society (i.e. all parties co-evolve). Schools rely on multi-channel

communication and effective networking internally and externally, and indeed, as they provide a human service, networking and relationships are important. (Morrison, 2005 p. 316)

Where the research in complexity and education lacks a clear explication of the relevance of complexity theory is in relation to the treatment of the 'class' as a complex system (Harding, 2010), potentially because of the relatively small numbers of students that make up a class. This question has been resolved in the literature by turning to the notion of nested complex systems. The argument lies in the importance of relationships between different levels of complexity, where complex systems are loosely defined with open boundaries, rooted in the insight that complex systems are irreducible (i.e. any attempt at reducing or simplifying the complexity at any given level of emergence results in an incomplete representation of the system because 'the whole is more than the sum of its parts') and are themselves made up of complex systems interacting with each other dynamically to result in the complex system at the level of consideration. This is neatly represented by Davis and Sumara in the first two diagrams shown in Figure 2 below.

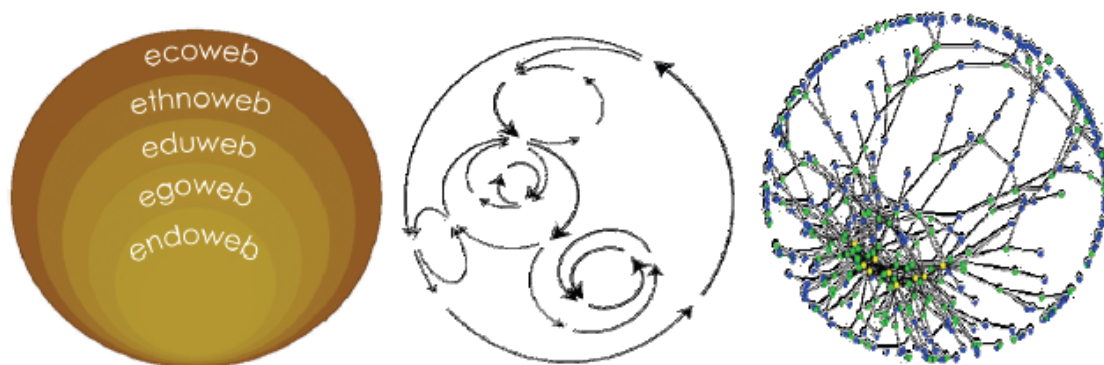


Figure 1. Three important visual metaphors within complexity research corresponding to the major emphases within three phases of the movement – (a) nested systems, (b) entangled dynamics, and (c) decentralized networks.

Figure 2: Visualisations of complex systems, taken from Davis and Sumara (2012), p. 31

In this conceptualisation, the complexity of the brain in the individual learner is understood as one level of emergence within the wider complex system that constitutes the class, within the wider complex system that constitutes the school. Of course, these groupings reflect the formal organisation of schools, which can be viewed as a form of complexity reduction since these structures can be seen as top-down rather than self-organising (for more detailed discussion of complexity reduction, see later section in this chapter, section

2.3.3). Alongside nested levels related to formal school organisation, a similar argument can be made with relation to explicitly self-organised groupings within schools such as friendship groups, voluntary activity groups and so on. The argument that is pertinent for the current discussion is that the interaction of individuals who are themselves seen as complex systems cannot result in a less complex system when the addition of the unpredictability of their emergent actions as complex systems *in interaction with each other* is considered. McMurtry makes this point, highlighting the recognition by teachers that classes have ‘personalities’ to suggest that it is feasible to treat a ‘classroom collective’ as a complex system (McMurtry, 2008 p. 275). A similar argument, and similar diagrammatic representation, is given by Haggis (2008) in her discussion of complexity theory in relation to case studies of adult learning in higher education contexts (see Figure 3).

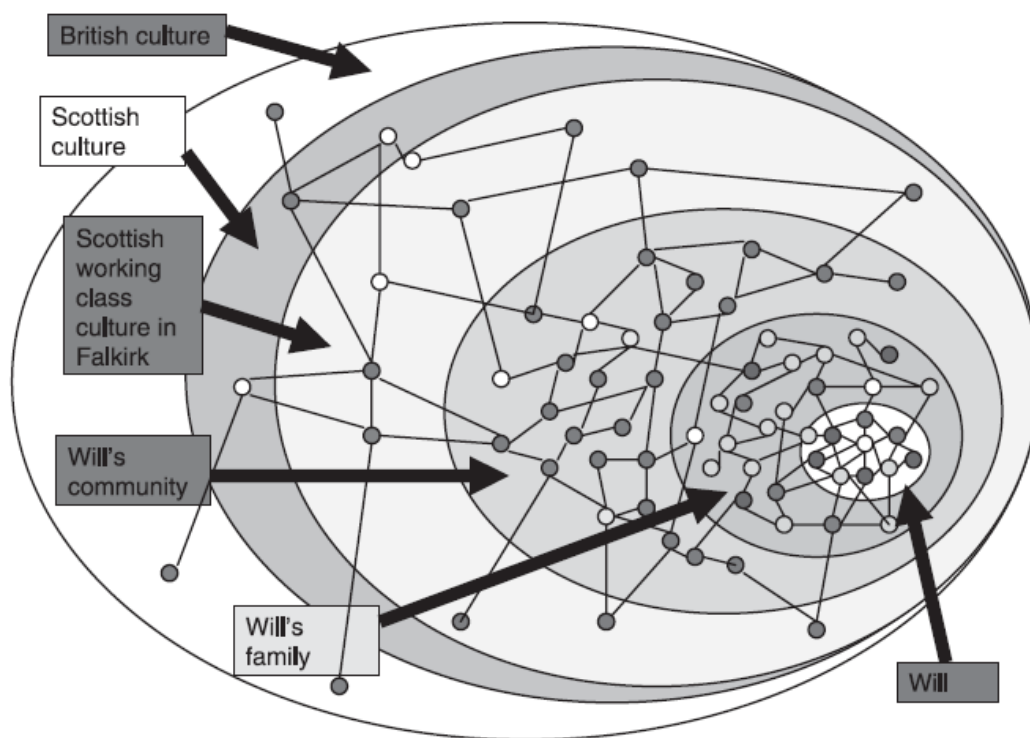


Figure 3: Visual representation of a complex systems view of a learner in higher education, taken from Haggis (2008) p. 171. The white circle represents Will, with the interconnected small dark dots representing different interactions, and the wider circles showing some of the systems within which ‘Will’ is nested.

These arguments engage with the logic of thinking about educational systems in complex terms, but crucially it is important to maintain awareness of the ‘level of complexity’ on which one is focussing and how that level relates to other complex systems and levels with which it interacts (McMurtry, 2008). At the same time, it is important to remember that it is

impossible to represent any complex system fully as the process of representation must involve some simplification (Cilliers 1998). The impossibility of such representation has led educational complexity theorists towards the use of complexity theory as a metaphor to provide a heuristic for understanding rather than an attempt to 'represent the unrepresentable' by modelling schooling in an attempt to predict (and control) the behaviour of education systems. Thus, the line of argument followed in much of the literature on complexity and education is that it is valid to think about learning, schools and education in complex terms, but that since detailed modelling and understanding of such systems is impossible, that doesn't mean there is no point in paying attention to complexity, as the ideas of complexity are useful as a metaphor to guide thinking about educational practices. As Davis and Sumara put it,

The contributions of complexity thinking to education and educational research are not necessarily direct ones. Nevertheless, some important principles can readily be adapted to the particular concerns of educationists...the project here is not to represent reality, but to participate mindfully in the unfolding of new possibilities for action and interpretation. (Davis and Sumara, 2006 p. 76)

The second critique found in the literature in relation to complexity and education is that it is unnecessary to appeal to complexity to theorise ideas of unpredictability, decentralisation, collaboration and interaction, as these ideas are well-represented elsewhere. Hunter and Benson made this argument in relation to early work which argued for the application of chaos theory to education (Hunter and Benson, 1997). These authors make the point that whilst they agree that overly mechanistic approaches to education are misguided, these issues have already been raised by, for example, constructivist theories of education, and the use of ideas directly translated from the natural sciences is also narrow and misguided. Their critique did not initially take into account the work of early complexity and education scholars such as Bill Doll, but although the postmodernist interpretations of complexity are more sophisticated than the original uses Hunter and Benson critique, they maintain the position that such interpretations are not necessary as others have already done this work without recourse to language from the 'new sciences', citing Whiteheadian process philosophy and constructivism as examples. This argument is also discussed by others (Kuhn, 2008, Morrison, 2008). Kuhn provides a rebuttal of this argument, suggesting that it is rooted in what she calls 'boundary-keeping activity' and proposing that an

alternative language with which to express ideas need not be redundant, as 'to use different language is to construct different meaning' (Kuhn, 2008 p. 184) and therefore provides a possibility of new insights and interpretations.

The final criticism of complexity theory in education found in the literature is rooted in a concern that ideas developed in the natural sciences cannot be directly applied to social sciences because of the unique nature of human agency (Hunter and Benson, 1997, Kuhn, 2008). However, if complexity theory as it has arisen in the natural sciences is taken seriously, then it contains a rebuttal to this argument in itself, because it suggests that 'nature itself turns out to be more like human nature – unpredictable, sensitive to the surrounding world, influenced by small fluctuations' (Capra, 2005, cited in Urry, 2005 p. 7). For some educationalists, there is something uncomfortable about the hegemony of the natural sciences as the path to rigour and validity in social research (Radford, 2008, Gough, 2012), while others argue that the relationship to other scientific ways of knowing is one of complexity's strengths (Horn, 2008). Drawing on Davis and Sumara's work, it is possible to advocate the pertinence of complexity theory to human endeavour as well as to natural systems through the suggestion that humans are *part of* the natural world and that what makes humans unique in their consciousness and awareness of that world is in itself an emergent phenomena. An alternative argument is that although the umbrella of complexity and its direction of attention to unpredictable, open systems and non-linear interactions might have originally stemmed from the natural sciences, the range of discourses under the complexity umbrella are not all alike. Thus, complexity in social sciences and education is not simply a direct translation of concepts and techniques developed in science, as demonstrated by the alternative approaches in educational complexity theory that are not rooted in computer modelling of complex systems as is common in science.

In this section, I have summarised some key criticisms that have been raised in the literature in relation to the use of complexity theory in educational research. I have attempted to review the reasoning the complexity and education literature offers for their use of this theory, identifying where this reasoning is not strong, and where I feel it is clear that complexity offers a useful alternative approach. There is one aspect of the critique of complexity theory in education that I have not discussed here, namely the idea that complexity is ethically 'silent' as a logical corollary of its concern with unpredictability, local

concerns and survival. This issue is addressed separately, particularly through the work of Fenwick (2009a) and Osberg (2010b), in chapter 4, where I discuss the ethical issues associated with this work. In the following section, I consider some of the ways in which educational researchers have made use of complexity theory, focussing in particular on Davis and Sumara's and Osberg and Biesta's work in developing an orientation towards 'complexity thinking'.

2.2.2 Developing 'complexity thinking' in education

The literature that has developed in the area of complexity theory and education can be grouped into three key areas: descriptive, pragmatic, and philosophical/theoretical. It should be made clear, however, that in grouping the literature in these ways I am not suggesting that there is no overlap and interaction between them – there often is, with researchers moving from description to pragmatic advice for action or from description to implications for new theory. In the following discussion, I merely use these areas as markers to help structure the account. There is insufficient space in this work to discuss the research done in these areas in great depth, and I have made use of this literature throughout the thesis in developing particular lines of argument. I provide here a brief summary of this literature before concentrating on the development of 'complexity thinking' in the work of a few key authors.

Philosophy threads throughout complexity theory because complexity asks ontological and epistemological questions in reconsidering ways of thinking about the world, such as the separation of mind and body. This has led to work within educational philosophy and theory that considers the implications of complexity theory for education and educational research. For example, a special issue of the journal *Educational Philosophy and Theory* examined the implications of complexity in light of reinterpretation of the work of key thinkers such as Foucault (Olssen, 2008) and Dewey (Semetsky, 2008), the importance of context in ways of knowing (Haggis, 2008), the nature of truth (Radford, 2008) and the role of representation in education (Osberg et al., 2008), amongst other aspects. Complexity theory has also been related to other educational theories such as sociocultural theories (McMurtry, 2006) and constructivism (Smitherman Pratt, 2008b, Proulx, 2008). Such work has explored insights from complexity theory and offered some directions for future research using a complexity

perspective, making arguments for the implications of this theorising for educational practices.

Alongside this theoretical work, much of the work in complexity and education has focused on the description of aspects of education as complex systems, and the sorts of distinctive insights these descriptions afford. This has included consideration of learning in the domain of particular subject areas (Davis and Simmt, 2003, McAndrew, 1997, Yoon, 2007), experiential learning (Fenwick, 2003), digitally-enhanced classroom environments (Ellis et al., 2005), school departments (Beswick et al., 2007), school reform (David, 2001) and curriculum change (Morrison, 2003, Doll, 1986, Slattery, 2006). The value of this descriptive work lies in the ways in which such descriptions might prompt us to think differently about the policy and practices of education, and also in the contribution such description can make to the broader work of educational theory *and* complexity theory. In particular, these authors use descriptions of educational settings using complexity theory to start to dissolve some of the binary separations and distinctions with which much educational discourse is concerned, in order to move forward in new directions.

It has been argued that since complexity theory is essentially descriptive and concerned with characterisation of the way things are, it is difficult to usefully apply these ideas to a field such as education which is ultimately concerned with taking action (Davis and Phelps, 2007). If complexity means that outcomes are indeterminate and unpredictable, and education is essentially a normative activity, the question is asked: what guidance can complexity-informed theorisation and description offer to shape future action? Attempts have been made to address this question in both theoretical and empirical work. Theoretically, Deborah Osberg has worked on this problem and uses principles of emergence to highlight ways in which teachers can take responsibility for an uncertain future through their work with students (Osberg, 2010b) and through the creation of a 'non-normative, normative curriculum' (Osberg, 2009b) by taking responsibility for opening spaces for new learning and new subjectivities to emerge. Empirically, researchers have begun to research interventions which advocate consciously creating and maintaining an openness to complexity and emergence in classrooms by creating interactive and experimental environments which confront students with the unfamiliar (Bloom and Volk, 2007), and through dialogue in relationships and interactions (Semetsky, 2005, Blackman,

2008, St John, 2000). The research undertaken for this thesis effectively follows the descriptive trend in complexity and education, by exploring a case study of curriculum change using a complexity theory framework in order to offer new insights into both educational practice and complexity theory in the context of education. The complexity theory orientation of this work is rooted predominantly in the work of Osberg and Biesta, and Davis and Sumara, and takes the view that although a complexity approach cannot offer a guide for an unpredictable future, research in this area can support new explorations and enable emergence of alternative futures in different ways.

In their book *Complexity and Education*, Davis and Sumara (2006) consider the question of what a complexity thinking orientation to educational research allows us to do differently, moving from a descriptive to a pragmatic approach to complexity-informed education. They argue that complexity theory suggests that in the study of complex systems, one must pay attention to both the system itself *and* to the interactions and conditions of the emergence of that system. In educational terms, this would translate as the need to pay attention to *both* the learning of a 'classroom collective' *and* the learning of the individual students and the context, curriculum, location and relationships between these elements at the same time. Davis and Sumara call this 'level-jumping' and suggest that this is a key methodological difference between complexity-oriented research and mechanistic research. Level-jumping also implies a reinterpretation of much educational theory, which is concerned with a focus on learning at one particular level. In education, complexity theory means, for Davis and Sumara, that binary distinctions between educational theories are undermined. For example, the distinction between focussing on the individual learner in constructivist discourses and the focus on the social collective in sociocultural theories is limiting, and complexity's requirement that both individual and collective learn *together* moves these research discourses in a new direction. The argument that complexity thinking undermines the distinctions and separations common in educational research leads them towards the identification of some 'vital simultaneities' where they suggest that attention must be paid to both parts of the binary in order to move forward in our understanding (Davis, 2008). Examples of important vital simultaneities identified include the relationship between 'knower' and 'knowledge', the relationship between different disciplines or 'ways of

knowing', and the relationship between 'education' and 'research', all of which are examples that are important for the research presented in this thesis.

Alongside their discussion of the different approaches to education and educational research prompted by an orientation to 'complexity thinking', Davis and Sumara suggest that complexity theory can offer pragmatic guidance for education. To be able to do this, they need to define what they understand education to *be* within a complexity framework. Davis and Sumara associate education with *emergence*:

'Education – and, by implication, educational research – conceived in terms of expanding the space of the possible rather than perpetuating entrenched habits of interpretation, must be principally concerned with ensuring the conditions of emergence of the as-yet-unimagined' (Davis and Sumara, 2006 p. 135)

In their work, Osberg and Biesta take a similar line in relating education to emergence, in which *education as strong emergence* (also discussed in Biesta's work in non-complex terms as education as 'coming into presence as a human subject') is distinct from other purposes of schooling such as qualification and socialisation, or from either unguided learning or planned enculturation (Biesta, 2006, Osberg, 2005b, Osberg et al., 2008). In their argument, a complex epistemology – complexity thinking – is incompatible with a linear understanding of education as identifying a particular goal (acquiring particular knowledge or skills or even attributes such as creativity) and then moving along a pre-definable linear path to get there. Instead, complexity thinking means that the only knowledge available about who educators are working with and the goal of their activity '*is a product of the emerging situation itself*' (Osberg, 2005b p. 82). Education therefore takes place within a relationship (typically but not necessarily between teacher and student) which Osberg calls a *space of emergence*, and Biesta calls the 'gap' in which education takes place (Biesta, 2004). The education that occurs within this space of emergence is unpredictable rather than pre-determined because participants in the educational relation become something/someone new through their interaction in this 'space'. Osberg and Biesta argue that this space is an educational space because although it is unpredictable and emergent, the shaping of human subjectivity in this space is not arbitrary, because to engage in education is to effortfully maintain an openness to difference and novelty – in Davis and Sumara's terminology, education is about an orientation to expanding the space of the possible and the not-yet-imagined. The other reason why complexivist education within a 'space of emergence' is not arbitrary is because

of the nature of embodied history within a complex adaptive system. One of Cilliers' characteristics of complex systems is that 'they evolve through time...their past is co-responsible for present behaviour' (Cilliers, 1998 p. 4). Historical analysis of a system can *explain* the present but cannot be used to *predict* the future development of the system. The embodied history within each individual engaging in an educational relationship means that the emergent subjectivities, whilst not predictable, are also not arbitrary as each brings something to the 'space of emergence'.

The work of both Osberg and Biesta, and Davis and Sumara identify education with emergence, and as a result offer heuristics for action in educational settings. Osberg and Biesta focus on distinguishing between actions in educational settings such as schools that are truly educational, in the sense that they enable something new to emerge, and actions that are occupied with non-educational activities they term enculturation (and which remain tied to linear and reductionist practices of education). The responsibility of teachers is moved away from planning and teaching in ways that enable students to reach particular goals and instead becomes one of working within their relationships with their students to challenge them with new ideas - with 'difference' - to enable them to 'come into presence as unique human subjects'. Edwards neatly summarises the practice Osberg and Biesta are advocating as 'practices of constant experimentation in response to others rather than aimed at fulfilling ultimate purposes as ends.' (Edwards, 2012 p. 159) This pragmatic approach to education is labelled a 'pedagogy of interruption' in Biesta's work (Biesta, 2006) and later a 'pedagogy of invention' in their joint work (Biesta and Osberg, 2007). Davis and Sumara also relate the pragmatic advice they offer to emergence, but are less concerned with the education of individual human subjects as with the creation of conditions of emergence within classrooms (through, for example, action research) to enable emergence across a range of levels of complexity. They do this by identifying some 'conditions of emergence', some characteristics that need to be in place in order for emergence to occur, which are summarised in Table 4. However, even whilst offering these guiding thoughts, Davis and Sumara note that complexity cannot be 'scripted into existence' by following rules, instead suggesting that paying attention to these conditions of emergence, emergence might be 'occasioned' with, of course, no guarantees.

Table 4: Conditions for Emergence drawn from Davis and Sumara (2006) Chapter 7

Pairs of 'conditions for emergence'		Implications
Internal diversity	Internal redundancy	For emergence, there must be diversity within a system, so that individual elements are confronted with difference. At the same time, there must be redundancy – the elements must have enough in common for meaningful interaction/communication to be possible. The dynamic balancing of diversity and redundancy means it is important to pay attention to both parts and whole.
Neighbour interactions	Decentralised control	Neighbour interactions of ideas and representations as well as interactions of people as agents within the system are important and need to be fostered – related to the idea of the 'complex conversation' (Pratt and Trueit, 2011). One way of fostering such interactions is through decentralised control of interpretive possibilities, so that authority is distributed amongst agents and emergent collective knowing is enabled
Randomness	Coherence	The balance between randomness and coherence that is necessary for emergence is given the label enabling constraints . The notion refers to the balance between sources of coherence (which can be seen as constraints external to that particular systemic level) that allow a collective to maintain an identity, and sources of randomness and disruption that require the system to adjust, adapt and emerge.
Davis and Sumara also point to other conditions of emergence that they do not discuss in such depth because they are less relevant as means by which educational emergence can be effected. These include feedback loops, the possibility of catastrophic system collapse, the means of preserving information as embodied histories of the system, a measure of stability under perturbation even whilst far-from-equilibrium, and reproductive instability. See Davis and Sumara, 2006, p. 151.		

'Complexity thinking' in education, drawn out from the work of these key authors, makes a clear link between educational action and emergence. Earlier in the chapter, I argued for the logic of using complexity approaches to explore education systems, but in continuing that exploration in this work it is important to remember that the habitual framework for understanding education in schools remains rooted in mechanistic sensibilities and includes orientation to qualification, socialisation and enculturation. This can be considered a form of

‘complexity reduction’, which is discussed later in this chapter. In developing an orientation towards complexity thinking in education for this work, I draw on the material in the literature highlighted above to consider the ways in which education-as-emergence is found in the case study, and ways in which it is not, ultimately considering how complexity thinking might offer alternative practices and ways of thinking for teachers working in a changing curriculum environment. In the remainder of this chapter, I draw on this work, and others, to create the theoretical framework with which I approach the case study of curriculum change that is the subject of this thesis.

2.3 A Complexity theoretical framework for researching a case of curriculum change

2.3.1 Relational emergence

Emergence relates to phenomena that arise from and depend on some more basic phenomena yet are simultaneously autonomous from that base. The topic of emergence seems both fascinating and controversial in part because emergence seems to be widespread and yet the very idea of emergence seems opaque or even incoherent. (Bedau and Humphreys, 2008 p. 1.)

The notion of emergence in complexity theory is, as suggested by the above quote, both fascinating and difficult to pin down. It is concerned with the creation of novel features in a complex system as a result of interactions within the system. The concept of emergence can be used in relation to both space (in terms of structure or organisation) and time. There are also different epistemological perspectives on emergence in the complexity literature that relate to the question of determinism and lead to the labels of ‘strong’ (indeterminate) and ‘weak’ (determinate) emergence (Bedau and Humphreys, 2008, Osberg and Biesta, 2007). In this section, I shall focus on a relational or organisational conception of emergence, putting aside questions of time for the next section. Whilst this separation is to some extent artificial, as both conceptions of emergence are important and change (and therefore time) is crucial for both⁶, it serves as a way of organising the argument presented before threading the notions back together.

By a conception of emergence in relation to space, I am concerned with the notion in complexity theory of different levels of organisation or complex structures that emerge as a

⁶As Cilliers notes, any analysis of a complex system that ignores the dimension of time is incomplete, or at most a synchronic snapshot of a diachronic process. (Cilliers 1998, p. 6)

result of interactions at lower levels in the system. I distinguish this from the temporal element of emergence because the different levels of organisation can be present concurrently: the lower level does not cease to exist when the new, emergent organisational structure appears. It still exists, but is *at the same time* part of the emergent phenomena. This can be illustrated through examples such as the economy, or the human brain (Cilliers, 1998). The human brain is viewed as a complex system in which consciousness emerges from the interaction of the different cells (such as neurons) that make it up. But these different levels of organisation – cells, brain, consciousness – all continue to exist at the same time, although the emergent levels of organisation cannot exist without the lower levels preceding them. Similarly, high levels of organisation within the economy such as the stock-market are co-existent and emerge from interactions between banks, co-existent with individual economic agents such as shops and individual traders. Again, the higher levels of organisation cannot exist without the lower levels from which they emerge and with which they continue to interact, so time remains an important factor, but emergent levels of organisation that can be depicted relationally do not succeed one another consecutively: the lower levels and higher levels exist in the same present.

Crucially, the notion of emergent levels of organisation and relationality in complexity theory is more than simply saying ‘a is made up of b, which is made up of c’, and so on, as that implies a simple reductionist relationship in which the whole is simply the sum of its parts. Understanding a system would then be a simple task of cutting the system into smaller parts to see how each of them works – an idea which has underpinned much scientific activity since the Enlightenment. Instead, each emergent level of organisation is more than the sum of its parts, since it ‘is not constituted merely by the sum of its components, but also by the relationship between these components.’ (Cilliers, 1998 p.2). At the same time, any complex system has ‘open’ boundaries and interacts with others, across the organisational levels within any system one might choose to define. Systems are not neatly nested, defined and separable but are instead multiple, overlapping and interacting. Analysis inspired by complexity theory must therefore seek to ‘understand’ at the different levels of complex organisation and the interactions between them rather than separate them out, as indicated by Davis and Sumara in the context of education (see section 2.2.2). Clearly this is a difficult if not impossible task, as any attempt at

understanding must entail some simplification of the complexity, but acknowledging the problem at least acknowledges that there must be gaps in any description or understanding reached. Instead, it is hoped that a complexity inspired approach must entail looking at the questions from a different angle that might support new insights even if it is impossible for such insights to be complete. An example of such an approach is that of Sylvia Walby (2007), who adopts complexity theory's orientation to emergent complex and multiple social systems to re-theorise intersectionality and thus offer a new perspective to debates in research into multiple social inequalities such as the interaction of gender and race.

'Relational Emergence' therefore resists a focus on any particular level of organisation without acknowledging the influence and importance of other levels. It resists both a reductionist *and* a holist perspective (Walby, 2007). I have resisted using the term 'organisational emergence' because the focus on the interactions and relations between systems appears, to me, to be the most fundamental idea in the arguments outlined above and a relational metaphor is for me the clearest way to distinguish this from the temporal characteristic of emergence I turn to shortly. In particular, self-organisation is a characteristic of complex systems important to emergence in a general sense, and I feel that the terminology 'relational emergence' avoids confusion with the notion of self-organisation, which the term 'organisational emergence' does not. In examining a school-based case study, the concept of relational emergence is important because of the way in which both students and teachers develop informal as well as formal groups and relationships which influence the learning taking place and the resultant development of the curriculum.

2.3.2 Temporal emergence

The concept of time in physics and philosophy may initially appear to be unproblematic: we all have a common-sense understanding of the passing of time, of movement from past to present to future, and of the standard measurement of time. However, further thought and even a brief scan of popular science literature leads to a more complicated picture of the conceptualisation of time in both physics and philosophy. Sandbothe (2001), argues that the physics of self-organisation, particularly the work of Nobel Laureate in Chemistry Ilya Prigogine, allows the development of a conception of time that may help to resolve the conflict between time in physics and time in philosophy. Prigogine's notion of time-

irreversibility has been used by educational theorists Deborah Osberg and Gert Biesta to rethink education through development of a 'logic of emergence', and this logic is used here in framing the idea of 'temporal emergence'.

Prigogine and Time-irreversibility

In his book, *'The temporalization of time: basic tendencies in modern debate on time in Philosophy and Science'*, Sandbothe (2001) contrasts the 'unifying and universalisation tendency' in classical physics with the tendency in philosophy to 'historise and relativise' time (from philosophers such as Heidegger, Mead, Whitehead and Ricoeur). In classical physics, time is a reversible construct. Sandbothe summarises the arguments of Prigogine and Stengers (1985), who outlined the basic features of the concept of reversible time. In classical physics, it is theoretically possible to determine exactly the position and velocity of any given object, which means that given sufficiently accurate measurement, it is always possible to predict what will happen and the mathematical equations that allow these descriptions and predictions are *commutable*, meaning that time is reversible. In other words, a reductionist and mechanical conceptualisation of physics according to universal laws of motion allows an understanding of change that can be fully described and mathematically modelled. Hence, both past and future movement can be described and 'time' is therefore reversible – the system can go forward or backward equally easily.

With the development of modern thermodynamics, the conceptualisation of time in natural sciences moved from a reversible understanding to an irreversible one, one in which the 'arrow of time' is uni-directional, moving from past to future and ultimately towards the 'heat death of the universe' as a result of entropy. At the same time, the development of quantum mechanics challenged both the premise that both position and momentum of a quantum object can be known with certainty (Heisenberg's Uncertainty Principle) (Prigogine, 1997) and, enshrined in the mathematics of quantum theory, the determinism of classical physics is undermined because the equations of quantum mechanics are not commutable – they don't give them same answer in both directions, leading to a concept of time-irreversibility (Kumar, 2009). Prigogine and Stengers took this concept of irreversibility further, and considered irreversibility in the context of open systems. They found that in such systems, it is possible for irreversible changes to result in more ordered systems. As a system moves further away from equilibrium in response to change imposed from the

'environment' external to the open system, it can spontaneously jump to a new level of order through self-organisation. Prigogine called such emergent ordered states 'dissipative structures' (Prigogine, 1997). Prigogine referred to the moments at which this 'jump' takes place as 'bifurcation points', where a range of possibilities that all meet the criteria of obeying the physical laws governing the system with the particular constraints of that system may be actualised. Rapidly increasing numbers of possibilities arise with each bifurcation point (reached as the system continues to move far from equilibrium), which again leads to further probabilistic 'choices' (although choice implies thought, and the path that is actualised is 'chosen' by chance, so perhaps this is not the best word). It can be seen from the above description that Prigogine and Stengers' approach to complexity thinking combines *both* the temporal *and* the relational aspects of emergence considered in this discussion, as their work combines the emergence of organisational structure in physical systems with the concept of time irreversibility through the action of chance and probability at moments of emergence (bifurcation points)⁷.

Such a move towards a greater level of organisation or order (as seen in Prigogine's dissipative structures) can be viewed as an example 'strong' emergence (Osberg and Biesta, 2007) not because of the fact of the emergence of an ordered 'dissipative structure' (which would fit with the notion of 'weak' emergence), but because the actual structure that appears *is a result of chance selection from a range of equally likely possibilities* that fit the physical laws governing the system and is therefore *impossible to determine prior to emergence*. In other words, emergence is a probabilistic occurrence rather than something that could be determined if it were possible to fully describe the system prior to emergence.

⁷ Note that the use of the term 'bifurcation' and the 'bifurcation diagrams' that can be drawn to represent this notion are used in different ways in different branches of chaos and complexity theories. Sarah Smitherman Pratt (SMITHERMAN PRATT, S. (2008a) Bifurcations are Not Always Exclusive. *Complicity: An International Journal of Complexity & Education*, 5, 125-128.) has argued that the use of the concept of bifurcation as described here is in contrast to the bifurcation diagrams resulting from mathematical functions in Chaos theory. In the context of mathematics, the possibilities produced at a bifurcation *both* occur – it is not the case that one is actualised in preference over the other. I think that the use of bifurcation diagrams in this sense is dealing with a different question to that under discussion here. In mathematics, the diagram produces a chaotic pattern of branching possibilities that are *determined* by the action of the mathematical function for a set of different initial conditions (for example in the production of fractals), and therefore time is removed as a factor in a similar way to the neutralisation of time in classical physics. A 'both/and' logic is possible in such an articulation of bifurcation that becomes impossible with the introduction of time-irreversibility in a Prigoginian understanding of emergence and successive bifurcations. Smitherman Pratt's problem with some complexity theorists' use of bifurcation diagrams relates to the suggestion that there is a choice *that implies prior intention*, but the indeterminacy of the notion of emergence prevents such an informed prior choice being possible, and therefore insists on a radical open-endedness in understanding the action of complex systems.

Prigogine's thought therefore moves thinking about time in the natural sciences away from both a reversible definition of time and a simplistic notion of irreversible time from order to disorder as determined by the 2nd Law of Thermodynamics, towards a conceptualisation of irreversible time compatible with the notion of strong emergence.

Embodied history in complex dynamic systems

The discussion in the previous paragraphs shows how a Prigoginian approach to complexity introduces a notion of temporal emergence alongside the relational conception of emergence. Through his studies of physical and chemical systems, Prigogine showed how novel and radically indeterminate structures appear in nature – a relational conception of emergence of new order, structure or organisation. His inclusion of the concept of time irreversibility also showed how emergence has a temporal element. This temporal element means that a complex system develops a trajectory that is by definition unpredictable when the system is far from equilibrium. A system under such conditions must continuously self-organise⁸ as time passes, which means that the history of the system is therefore embodied within the system itself, within the structure of the system. This concept of embodied history is perhaps best illustrated with a sketch (see Figure 4. Please note that this is not intended to be a 'bifurcation diagram' plotted from a mathematical function, but an illustrative sketch, using a Prigoginian conception of emergence, to aid thinking.) The sketch shows a system that is in an equilibrium state to begin. At each 'junction', there are a number of potential pathways, all of which are 'novel' and 'unpredictable' – they do not follow the equilibrium conditions of the past, and it is impossible to know what these possibilities are until they emerge. At random, the complex system takes a particular path (it must be random, as there is no way of knowing what will become of any path, so there is no basis for a pre-determined 'choice'.) As time continues forward, the system can develop along any of a range of trajectories, two of which are illustrated with the blue and purple lines. It can be quickly seen from this sketch that the blue and purple trajectories take the system in different directions, which will mean that each system, though beginning from the same starting point (the same initial condition) is different. The structures or inventions that

⁸ Perhaps in educational settings, the term self-create or self-invent, rather than self-organise, might be a more useful terminology as it foregrounds the agentic nature of social systems. This notion will be discussed in greater depth in Chapter 3, where the implications of the complexity theoretical framework developed here for ideas in social theory are discussed.

emerge over time depend on the previous trajectory and thus it can be said that the system embodies its history.

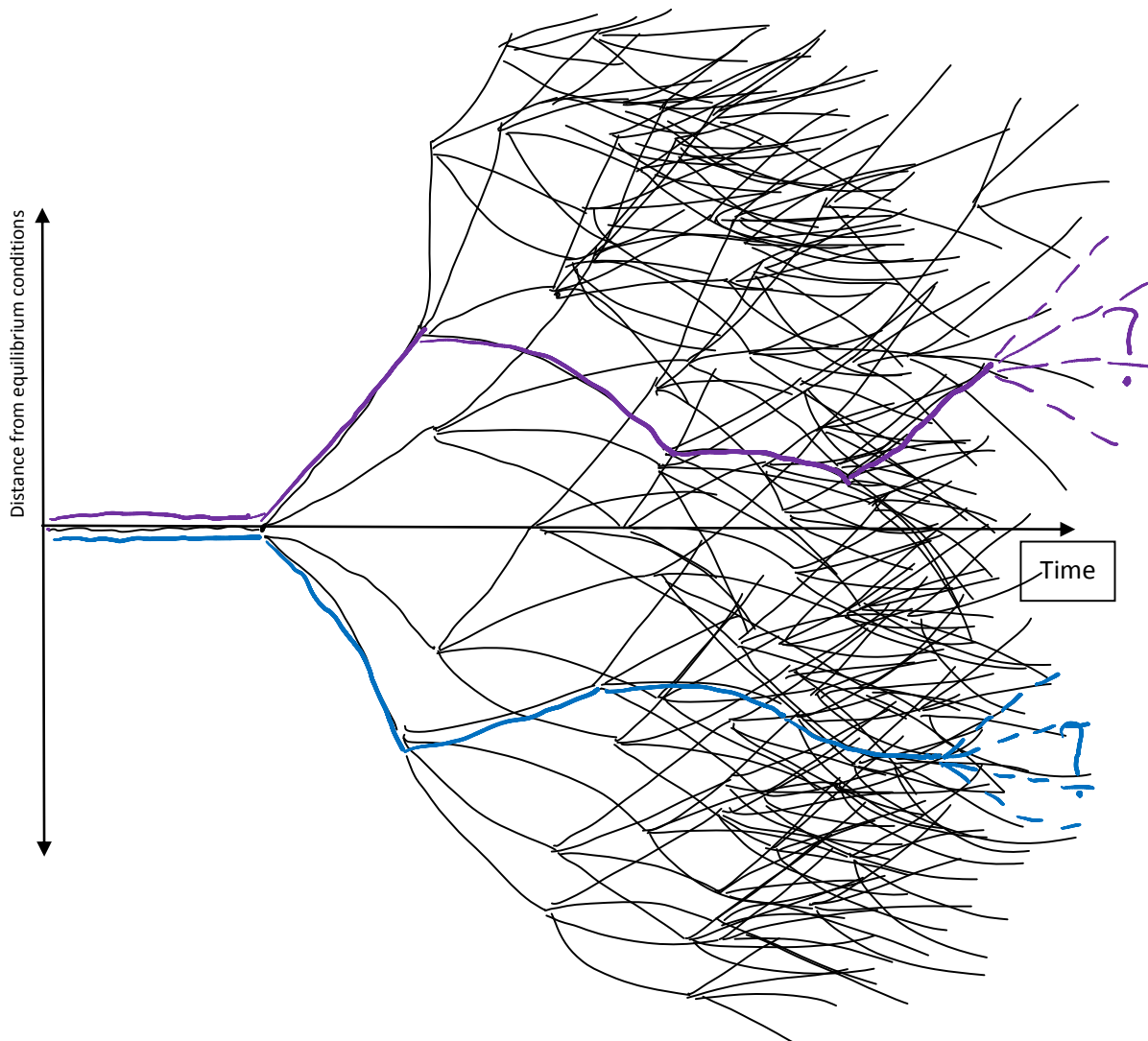


Figure 4: Sketch of possible 'trajectories' of complex dynamic system

This description may appear to suggest that the possible pathways or trajectories are laid out in advance. This is not the case. The history of the system works to constrain the potentialities of what may emerge, but do not *determine* either what those potentialities are, or which potentialities might be actualised. The nature of emergence (or at least, the strong emergence which Osberg and Biesta argue is created by Prigogine's theory of dissipative structures and time-irreversibility) is such that though the embodied history might place *constraints* on emergence, the potentialities that might appear from the particular 'present' of that system are radically uncertain until they emerge, and are not *determined* (in the sense that following emergence they can be fully understood in the

context of what went before – the sense that the effect can be linked to a particular identifiable cause in the prior state of the system). I shall return to the distinction between constraint and determination in discussing the third element of this framework: complexity reduction.

To return to Sandbothe's argument with which I began this section, the concept of embodied history within a complex system that arises as a result of the introduction of the temporal element of emergence (due to time irreversibility) provides a step that links the concept of time in natural sciences with a historicised and relativised conception of time in philosophy. Such a conception of time, linked to a notion of temporal emergence, is an important element in this framework because of the way time is approached in the school context. Education is commonly seen in terms of ages, stages of development, sequences of progression, discrete parcels of time allocated to particular activities and so on. Such a conceptualisation of time can be linked to an ends-based understanding of education, as opposed to an emergent understanding of education. This rethinking of the concept of time in an educational context is important in considering key ideas in social science such as reflexivity, agency and identity. I will return to this in Chapter 3.

Using a conception of temporal emergence to rethink stability, mechanistic change and emergent change

The discussion of Prigoginian complexity in relation to time as outlined above is important in considering the difference between stability, mechanistic change, and emergent change. The idea of equilibrium is an important one, here. A system at equilibrium is maintained in a steady state, but that does not mean that there is no movement. For example, in chemistry, a reaction at equilibrium is a reversible reaction where both the 'forward' and 'backward' reactions are occurring at the same rate, thus maintaining a steady amount of reactant and product (which requires a closed system, or one in which the inputs and outputs are fixed). This suggests stability over time, and in Figure 4 it might be represented by a horizontal line with no vertical component. I use the term 'mechanistic change' to denote a system that is changing, but in a way that is predictable based on the immediate past. An analogy here might be the addition of some more reactant to our previously closed chemical reaction at equilibrium. A change would be observed where the amount of product gradually increased until the reaction reached a new equilibrium position, and would be indicated on the sketch

by lines which curve from a diagonal back towards a horizontal line. The final term, 'emergent change' would be indicated on the sketch by the 'bifurcation points' at which a range of potential, indeterminate trajectories may arise in response to the system being maintained far-from-equilibrium. Taking our example of chemistry, this relates to Prigogine's dissipative structures in open systems that exchange energy with their environment. A dissipative structure emerges spontaneously in open systems that are far-from-equilibrium, but crucially, there are numerous possibilities of what might emerge at these bifurcation points that are all equally likely, and it is this that means emergence at a bifurcation point is unpredictable. By analogy, we can imagine a classroom operating in a stable fashion according to agreed rules of behaviour and where learning proceeds in a predictable way – this would be a stable system represented on the sketch by a horizontal line. The arrival of a new pupil would introduce a different set of possibilities (which could be bifurcation point), to which the system could adapt in a mechanistic way, using the rules and systems of the past, and this would be represented by a curved line on the sketch. The analogy with dissipative structures, bifurcation points and emergence would be where the system is not closed but is *kept* in an out-of-equilibrium state by constant confrontation with new information which enables emergent possibilities. In the work of Osberg and Biesta, this is the responsibility of the teacher, who needs to constantly challenge students by confronting them with the unknown, the novel, and the different.

My sketch, which is modelled on the bifurcation diagrams often drawn by complexity theorists, is a limited representation as equilibrium is a common feature whereas Prigogine argues that equilibrium is a rare occurrence in natural systems. However, what the sketch diagram *can* show is that in an open system, emergence at a bifurcation point is always potentially possible even though the system might appear to be in a steady-state period of mechanistic change. Despite its failing (partly because any attempt at representation of such a complex system is bound to oversimplify), the sketch remains a helpful representation to illustrate the notion of embodied history and the relationship between closed-system stability, predictable, mechanistic change and unpredictable, emergent change.

The 'logic of emergence'

The preceding discussion develops a conception of emergence that foregrounds time and history rather than (or alongside) emergent structure and organisation. This temporal

notion of emergence, related to 'strong' emergence, has been used by Osberg and Biesta to develop a theorisation of education rooted in complexity, in which both meaning and human subjectivity are viewed as emergent phenomena. I touched on this in my earlier discussion of complexity theory in relation to education, and now outline their ideas further in relation to the framework of temporal and relational emergence developed here. Osberg and Biesta's (2007) move makes use of the indeterminacy within the 'logic of emergence' in a Prigoginian approach to complexity to enable us to consider phenomena such as meaning and human subjectivity as emergent. This use of a 'logic of emergence' highlights the importance of including the temporal notion of emergence within this theoretical framework, as the case of an emerging curriculum is concerned with 'education' in the sense described by Osberg and Biesta *as well as* emerging curriculum and organisational structures within the school. In this way, it allows us to consider complex systems as 'self-creative' or 'self-inventive' as well as 'self-organising'.

A fundamental principle in the 'logic of emergence' (Osberg and Biesta, 2010, Osberg et al., 2008) is that of open-endedness. The version of 'strong' emergence Osberg and Biesta use in their argument (informed by Prigogine and therefore temporal in nature as described above) means that emergence is radically indeterminate. This logic therefore requires us to 'rethink' education in an open-ended way. This contrasts with the usual conceptualisation of education as ends-based, which Osberg and Biesta argue is a form of *enculturation* rather than a form of *education* (Osberg and Biesta, 2008). For education to be 'educational' rather than a form of unguided learning, then it must have some purpose. An emergentist framework questions the possibility of purpose in complex systems, thus raising the question of whether *education* is truly possible. Osberg and Biesta resolve this question by using the logic of emergence in a double sense, to refer to emergence in meaning-making and at the same time emergence of human subjectivity. The first sense in which the logic of emergence can be put to work in rethinking education is in relation to meaning. Rather than the educational act being the transfer of already-understood meaning from teacher to student, meaning emerges for students in unpredictable and indeterminate ways. This use of the logic of emergence shifts the responsibility of the educator away from simply providing answers, to using knowledge to challenge students and encourage new questions, so that students are able to create their own meaning. However, as Osberg and Biesta point

out, 'an emergentist conception of meaning is *not sufficient* to release education from the logic of socialisation/enculturation' (Osberg and Biesta, 2008 p.320). They suggest that, due to the relationship between meaning and human subjectivity, unless the logic of emergence is *also* applied to subjectivity then education is still focused on the production of particular meanings that relate to particular subjectivities imagined to be 'good'. However, using the logic of emergence in relation to both meaning-making *and* subjectivity, the focus of education moves away from working for a particular 'good' subjectivity (even through open-ended meaning-making) because it is impossible, from an emergentist perspective, to conceive of what subjectivity may emerge. Education then becomes about opening up a 'space of emergence' whereby students are challenged to both create their own meaning and 'come into presence as unique individuals', rather than learn pre-existing understandings and train up as particular sorts of people. The former, Osberg and Biesta would designate as 'educational', whereas the latter is viewed as 'enculturation' or 'socialisation'. They do not suggest that functions of schooling that are constituted as socialisation, enculturation or qualification are unnecessary or bad – simply that they are not educational (Biesta, 2006). It is possible to relate this distinction, between what Osberg and Biesta see as educational as compared with some alternative functions of schooling, to the distinction between stability, mechanistic change and emergence in my earlier discussion, as mechanistic change can be seen as relating to enculturation rather than emergent educational practices. This is an important consideration in relating the theoretical ideas discussed in this chapter with the unfolding of the research case studied for this thesis.

Alongside their use of emergentist logic to reconsider what is 'educational', Osberg and Biesta also make use of the logic of emergence developed using this particular understanding of temporal emergence to argue for an alternative way of thinking about curriculum, where curriculum is oriented towards process through a 'guiding role', rather than prescribing particular ends or aims for education (Osberg and Biesta, 2010). Osberg also uses this shift in thinking about education to re-consider what constitutes responsible action in education if there is no possible pre-conceived notion of a 'good end' towards which we should orient our actions. The work of these authors shows how the logic of emergence that is shown by incorporation of a temporal as well as a relational

conceptualisation of emergence creates a new and different epistemology for thinking about education in a variety of ways. This epistemology of ‘complexity thinking’ in education is a crucial part of the theoretical framework for the current work.

2.3.3 Complexity Reduction

The third element in the theoretical framework for the study is the concept of ‘complexity reduction’. In previous sections I have discussed and developed concepts of relational and temporal emergence, drawing on ideas from a range of complexity theorists but particularly the work of Ilya Prigogine, re-cast in an educational context by Osberg and Biesta as a theory of ‘strong emergence’. These two conceptualisations use notions from complexity theory of non-linear dynamics, recursion, difference, positive feedback and indeterminism to consider the emergence of the unknown as a result of interactions between elements in a complex system under far-from-equilibrium conditions. Much of my earlier discussion of complexity theory explored these ideas in complexity theory in general and in relation to education in particular, but the key point in this section has been to discuss how a particular way of thinking about emergence might be used as part of a framework developed for examination of a particular case of curriculum change. However, alongside these notions of emergence in a complex dynamic system, we must also consider ways in which it appears that complexity in social systems is reduced through a range of mechanisms. This is important in relation to education and schooling, as numerous authors (e.g. Simons and Olssen, 2010, Biesta, 2010a, Frelin and Grannas, 2010) have noted that aspects of the school system, including timetables, curricula, classroom organisation and layout, and school hierarchies, all contribute to the reduction of the potential complexity of schooling, or mitigate against ‘conditions for emergence’ in various ways. In the following section, I discuss ways of defining complexity reduction within the framework of relational and temporal emergence already developed, and consider why the inclusion of a concept such as complexity reduction is necessary in the developing framework to enable a focus on concepts such as power and authority in a school setting.

What is complexity reduction?

If complexity is characterised by rich interactions between large numbers of diverse elements within open systems, with the operation of positive and negative recursive feedback loops influencing these interactions, then ‘complexity reduction’ can be viewed as

acting against these 'features' of complexity appearing or continuing. Biesta (2010a p. 7) takes this line in defining complexity reduction as having to do with a) reducing the number of 'options for action' for 'elements within a system', and b) impacting on the recursivity of the system by constraining the language used in the system. Complexity, and thus the potential for emergence, may be reduced or constrained through, for example, minimising the interaction of a system with its environment through minimising the opportunity for interaction within the system, or through decreasing the number of elements within the system. The implications of such complexity reduction on the type of emergence I have characterised as 'relational' is clear, but alongside this we must also consider the implications of complexity reduction on the 'temporal' conception of emergence. Again, this can appear straightforward at first glance: actions that maintain the system close to equilibrium are likely to constrain the possibilities for emergent phenomena. However, as Biesta (2010a) argues in the third of his 'five theses of complexity reduction', recursion and reflexivity result in the potential for complexity reduction to act *both* prospectively *and* retrospectively, with interesting results for a temporal conception of emergence.

Complexity reduction in education happens prospectively (through the reduction of initial variables) but also retrospectively (through backwards selection of particular trajectories). One of the most explicit examples of retrospective complexity reduction in education is assessment, because assessment validates some learning trajectories and invalidates others, but always does so "after the event". Because education is a recursive system, anticipation of assessment also reduces complexity. In this way assessment also functions prospectively in the reduction of complexity. The question who might or will benefit from these forms of complexity reduction is, again, an open question. (Biesta, 2010a p. 9-10)

The suggestion that complexity reduction works both forwards and backwards in time does not relate easily to the conceptualisation of temporal emergence in which what follows after emergence is unpredictable – *unknowable* – before it has emerged. In this sense, complexity reduction indicates the working of a system during what I have termed 'mechanistic change'. Biesta discusses this problem of relating retrospective complexity reduction with strong emergence in the fifth of his theses. He resolves this by arguing that the probabilistic, undetermined 'choices' made at the point of emergence choose a particular 'outcome' or trajectory, and the 'identity' of the trajectory that led up to the choice is *changed* as a result of that choice. Quoting Mead, the past 'must always be set over against a present in which the emergent appears, and the past, which must then be

looked at from the standpoint of the emergence *becomes a different past*' (Mead, 1932 p.2, cited in Biesta 2010a p. 12). This does go some way to resolving the idea of an emergent, indeterminate future with the suggestion that complexity may be reduced through a process whereby reflections on the past and present influence activity oriented toward the future and thus reduce the perceived 'options for action'. However, this resolution seems in some way insufficient. This argument appears to suggest that after a *particular* future has emerged at a bifurcation point, the past (or perception of the past) that led to that choice of future is altered such that the choice became in some way determined by the original trajectory, thus reducing the complexity. This implies that after the appearance of emergent phenomena, the system's past is altered such that this was not emergent at all – or at least becomes an example of weak rather than strong emergence.

I would argue that using the framework of relational and temporal emergence developed thus far, the question of complexity reduction acting both prospectively and retrospectively may be resolved through an understanding of change over time as a combination of both *mechanistic change* and *emergence*. As discussed in the previous section, mechanistic change during a period of relative stability suggests the action of a normative framework that is fundamentally disrupted as a result of emergence, where a new, radically different normative framework is created that is not determined by what went before. Working with this perspective, it is possible to develop a notion of complexity reduction that can act both prospectively and retrospectively within a period of mechanistic change. However, if complexity is not reduced so far that emergence does not occur, then temporal emergence at a bifurcation point (or 'strong' emergence) cannot be disrupted by the action of retrospective complexity reduction, as after emergence, the normative frame in which such mechanisms of complexity reduction might act is no longer relevant – the actions of the past may be re-thought in terms of the newly created/emerged framework, which, I believe, is Biesta's argument. But re-thinking the past in light of the newly emergent does not necessarily constitute a reduction in complexity in the same way that retrospective complexity reduction may act in the example of assessment. To illustrate this suggestion using the assessment example: assessments privilege particular knowledge, thus validating particular actions in the past and causing teachers to act differently in relation to the assessment in the future – an argument which holds during a period of mechanistic change.

In contrast, if the assessment takes place after a moment of emergence, the assessment cannot be held to validate particular actions in the past because after emergence, assessment within the trajectory of the past *prior to the moment of emergence* would not make sense in terms of the emerging present. New assessments in the newly emergent frame cannot use the assessment strategies of the past regime, as they cannot make sense within the unprecedented framework. In a similar way, prospective complexity reduction cannot 'cross' into a newly emergent frame, as once temporal emergence has taken place, the reduction in complexity that may have limited emergence is disrupted and is no longer relevant under the new conditions.

Is it possible to reduce complexity?

The preceding section may appear in part to have already answered this question in the affirmative, as in describing what complexity reduction *is*, I imply that reduction of complexity is possible. However, there is some question about whether it *is* possible to reduce complexity, and also whether or not thinking about complexity reduction is feasible within a 'complex' epistemological, ontological or methodological frame. Fenwick (2010b) characterises this problem clearly:

[Given the premise that] complexity is the primary condition of life. Interactions among all living elements are dynamic, non-linear and emergent. Therefore...predictability and consistency...may only be accomplished through reducing the complexity of the system, i.e. through limiting the number of possible variables and reducing the 'recursivity' of the system and its potential for emergence. But while it may seem natural to take this analytical step, how in fact do we analyse the concept of complexity reduction? Complexity theory itself may not be helpful...for it does not theorise its own absence. (Fenwick, 2010b p. 58)

Fenwick goes on to discuss the problem of theorising complexity reduction using complexity theory, which relates to the anti-reductionist line in complexivist thought. We can suggest that complexity reduction occurs through mechanisms which 'remove or inhibit' elements needed to produce complexity and emergence. But if we accept that 'the whole is more than the sum of its parts', then, as Fenwick suggests, 'the less-than-whole cannot simply be assumed to be the reduction or suppression of these parts'. Therefore, a simple assumption that complexity reduction entails the removal of some 'parts' of the complex system, which then prevents emergence cannot be reconciled with the concept of strong emergence in complexity theory. Fenwick resolves this limitation in complexity theory by adopting an

Actor-Network Theory approach to analyse ways in which the predictable, 'reduced complexity' and non-predictable educational complexity are performed together. This appears to be a rich and interesting approach, given the apparent parallels between the two theories that bring them into potentially useful dialogue. However, for the purposes of this work I would like to find a resolution of this question using complexity approaches rather than adopting complementary theoretical tools.

In discussing complexity reduction in relation to temporal emergence, I offered a potential resolution to the problem of whether complexity reduction can be reconciled with emergence by suggesting that complexity reduction cannot act across bifurcation points – points of emergence through time. During a period of mechanistic change, a system may be sufficiently complex to have the potential for emergence – such a system needs to be open, large enough, recursive, with a balance between diversity and redundancy, and so on. The system can be relatively stable, suggesting that some mechanisms are acting to maintain that stability, and these can be viewed as mechanisms of complexity reduction. However, *at the same time* (and I believe Fenwick's approach in analysing the interactions between complexity reduction and complexity production at the same time is insightful), a complex system *also* must have the *potential* for emergence. If this is not the case – if complexity is reduced so far that emergence is no longer possible – for example if the system is closed off from the environment – then complexity is no longer an appropriate theory for analysis. In this theoretical framework, then, I adopt an approach that maintains an open mind as to the balance and interactions between mechanisms that could be seen as reducing complexity and those which could be seen as producing it, and these interacting mechanisms can act throughout a period of mechanistic change. This, in combination with my assertion that mechanisms of complexity reduction cannot act *across* a point of temporal emergence because the 'rules of the game' have been changed, goes some way to resolving the question raised by Fenwick whilst maintaining a complexity framing. I accept that complexity may not be an appropriate theory for all analyses, and I choose to use a particular complexity-informed approach in this thesis to explore alternative ways of thinking about education, as a complex system.

Complexity reduction is therefore included as one of the three elements in this framework, but the question still remains: is it possible to reduce complexity? Framed differently: in a

complex setting, do actions that reduce complexity also produce complexity? In other words, can such actions make previously possible trajectories impossible whilst making possible others that were not possible before. This question arises in part because of the combined relational and temporal character of complexity, in which complexity acts over different scales and emergence is indeterminate and unpredictable. Rasmussen (2010) uses Luhmann's thought in the context of meaning to argue that complexity cannot be reduced, as any act of complexity reduction will at the same time produce new complexity. For Luhmann, systems (which may include schema or mental models held by learners) are operationally closed (to be defined as systems) but at the same time open to their environment, which must logically be more complex than the system itself. If the 'form' of the system (dividing the system from the environment) is 'made up of what is *actualised* by the system among everything that is *possible* for the system' (Rasmussen, 2010 p. 21), then new meaning is made through the environment impacting on the system's possibilities, which causes the system to make selections of the possible based on interaction with the environment. In this way, complexity is reduced through the act of selecting from a range of possibilities, but at the same time, the horizons of the system expand as 'a possible' becomes actualised and new possibilities emerge. Thus, both complexity reduction and complexity construction occur simultaneously (see Figure 5). As Rasmussen put it, 'paradoxically, the apple becomes not smaller but bigger for each bite taken' (Rasmussen, 2010 p. 23).

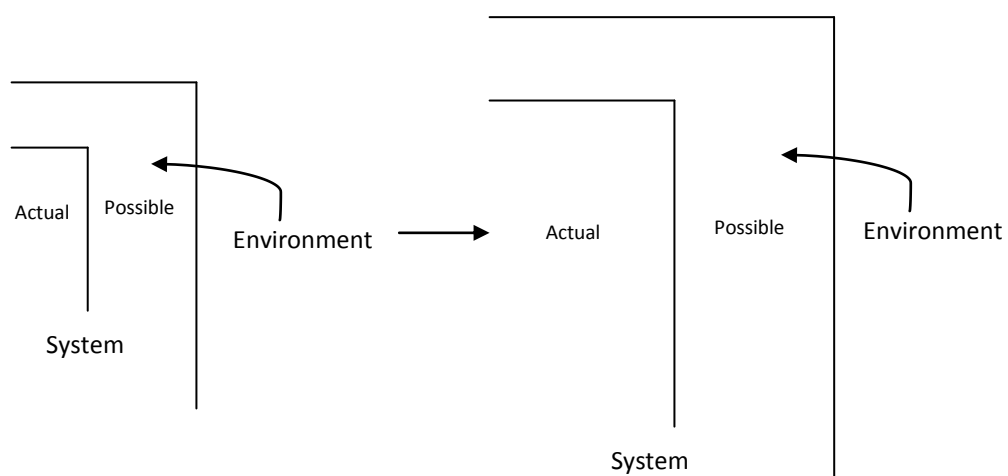


Figure 5: 'Enlarging the Space of the Possible', after Rasmussen (2010). As the system makes selections of the possible through interaction with the environment in a move of apparent complexity reduction, the actualisation of the system emerges and the space of the possible is enlarged, thus producing further complexity.

Since Rasmussen's argument builds on a Luhmannian conception of complex systems, a question arises over whether it is possible to translate this argument into the framing of complexity theory already outlined in this chapter. Does the conceptualisation of complexity reduction and emergence as developed above allow us to consider complexity reduction as a simultaneous and necessary process in the construction or production of complexity (and therefore emergence)? In 'enlarging of the space of the possible', to use Davis and Phelps' (2004) phrase, we can imagine the system/environment horizon on Rasmussen's diagram as moving outwards and draw a parallel between this and the expansion of possible (though indeterminate and impossible to imagine prior to emergence) trajectories in temporal 'strong' emergence building on Prigoginian complexity. We can also imagine the now-past trajectory as actualised, and therefore relate this to complexity reduction in that the history of the system is now embodied in its present as a particular trajectory resulting from particular choices, or actualisation of possibilities. This is a different understanding of complexity reduction, where that reduction occurs at a bifurcation point *when a particular emergent trajectory is chosen, and others are not*, and is compatible with the ideas of relational and temporal emergence outlined in this framework. This conceptualisation of complexity reduction is not the same as the notion that complexity is reduced by controlling a system so that fewer choices are available, which I have also considered within this framework as acting within periods of mechanistic change.

Biesta has suggested that the action of retrospective complexity reduction is reconciled with complexity thought through the past being re-imagined as a result of an emergent present, which could be taken to mean that there is still a breadth of complex and unpredictable ways of re-thinking the past (and therefore the past interacting with the present and therefore future system). Such an argument suggests that complexity reduction and production may occur in tandem, as what might be viewed as a reduction in complexity through the actualisation of an emergent present/future is also, at the same time, acting to increase complexity through re-casting or re-thinking of the past from a new perspective, thus fostering new interactions, broadening horizons and increasing the diversity of perspectives.

In the previous section on complexity reduction, I argued that it is not possible for complexity reduction to occur across an emergent 'jump', because emergence changes the

'normative' framework as the emergent frame is radically new. However, using Rasmussen's discussion of the simultaneity of complexity reduction and complexity production, I have also suggested that retrospective analysis of the past 'reduced-complexity', rather than implying no indeterminate emergence occurred because the past is changed by the future, allows instead the fostering, construction or production of complexity through the emergent future enabling us to 'think differently' about the past trajectories of the system, with such re-thinking contributing to the richness of interaction within the present. So, although complexity reduction in the mechanistic sense may not act across a point of emergence, the nature of a complex system's embodied history (and, in social systems, its awareness of that history) means that the interaction between past, present and future can be a form of both complexity reduction and complexity production.

In conclusion, then, this discussion of complexity reduction – its existence, theoretical positioning and mechanisms – suggests that for this theoretical framework, mechanisms of complexity reduction (such as assessment, curricula, timetabling etc) are seen as acting during periods of mechanistic change in tension with and at the same time as interactions which foster emergence and complexity. This will allow me to consider the implications of particular strategies observed in the case that appear to reduce complexity whilst at the same time highlighting ways in which such complexity reduction strategies appear to be subverted within the complex system of schooling that constitutes the case. Such complexity and the resultant emergence may be examined from interweaving concepts of relational and temporal emergence. Alongside this, a concept of complexity reduction across 'jumps' of temporal emergence is re-cast as simultaneous complexity production by opening different ways of thinking about the past.

Relational emergence and complexity reduction

The relationship between complexity reduction and a relational understanding of emergence must also be considered alongside the previous development of an understanding of complexity reduction in the context of mechanistic change and temporal emergence. Again, I turn to the question of whether or not complexity reduction is possible. The preceding discussion of complexity reduction explained the concept as one in which the 'features' of complexity (such as rich, recursive interactions within open systems) are minimised so as to prevent the opportunity for emergence, thus restricting a system to

mechanistic rather than emergent change, and therefore ultimately to stagnation. Within discussions of complexity reduction in relation to education, examples of complexity reduction that are structural or relational in nature are often cited, for example in the rigid implementation of national curricula (Gough, 2010, Gough, 2009). In such examples, top-down, outcomes based curricula are viewed as reducing complexity because they aim to prescribe particular knowledge and pedagogy as ‘good’ or ‘correct’ or ‘best practice’, thus minimising the options available for action by teachers and students in the classroom. Following this line of argument, complexity theory is used to make the point that it is crucial for educators to ‘generatively resist’ such reductionist tendencies in education and instead develop pedagogical practices designed to encourage emergence (for example, see Davis et al., 2007). The suggestion here is that it is possible to reduce complexity – to prevent emergence. However, following similar arguments to those made in the previous section regarding temporal complexity reduction, it is possible to suggest that the reduction of complexity is impossible from a relational or structural perspective, simply through the argument that complexity *is*. Life, and therefore humanity, is *necessarily* complex and emergent. If this premise is accepted (a big ‘if’), then it follows that those aspects of life or human action that appear to be reducing complexity must be part of complexity, albeit a part that may stagnate as a result of complexity reduction. Following Rasmussen (and therefore Luhmann), complexity reduction could instead be viewed as a process of simultaneous complexity production, through conceptualisation of structure as multiple, relational complex systems. Complexity reduction, as seen from an organisational level ‘lower’ in the emergent social system, occurs when an emergent higher level of organisation appears to ‘impose’ particular constraints on the elements of the lower level system. However, these constraints may result in unpredictable responses within the system at lower levels (and in the other open systems that interact with it as part of that particular system’s ‘environment’). These unpredictable reactions may in themselves result in changes in the higher level system through processes of recursion. Essentially, the argument is then made that relational emergence and apparent complexity reduction are intertwined phenomena, which themselves link to the concept of temporal emergence through the embodied history of the multiple, related, relationally and temporally organised complex systems. This notion will be discussed further in chapter 3 in relation to the interaction of agency and structure in social systems.

2.4 Summary

In this chapter, I began by considering the question of whether it is reasonable to treat educational systems as complex. Taking critiques from the literature, I argued that complexity theory can offer a particular approach to understanding education either through the use of metaphors from complexity science, or through a form of complexity thinking. I also provided a brief outline of the ways in which complexity theory has been taken up within education as raising philosophical and theoretical questions, as a descriptive tool, or as offering pragmatic advice for those working within education. I then took up the theme of complexity thinking apparent in some of this work, particularly the work of Davis and Sumara, and Osberg and Biesta, to outline some key ideas in the complexity literature of importance for this research. Finally, I drew on these ideas in complexity thinking to generate a particular theoretical framework for this research rooted in concepts of relational and temporal emergence and complexity reduction. In the next chapter, I begin to make use of this framework to re-think important ideas in social science which I need to use to explore and analyse the case study of curriculum change that is the subject of the empirical work of this thesis.

Chapter 3 - Complexity Thinking and Social Theory

3.1 Introduction

In chapters 1 and 2, I gave a necessarily brief background to complexity theory, highlighting the key features of an approach that could be labelled 'complexity thinking' in education. I then drew on these ideas to develop a theoretical framework incorporating concepts of temporal and relational emergence and complexity reduction. In the following chapter, I bring complexity theory into dialogue with some of the major ideas in social theory using this theoretical framework, with the intention of using these ideas to examine the evolving and emerging curriculum in my case study. I will outline how the elements of the framework developed in chapter 2 'act' on concepts in social science of relevance for analysing the developing and emerging curriculum: *agency (and its relationship to structure), power, identity/subjectivity and reflexivity*. These ideas have been developed and used by a number of social scientists. The discussion in this chapter illustrates some of the ways in which complexity theory ties closely with the ideas of some thinkers in sociology and education, alongside some of the differences a complexity-inspired approach suggests.

Concepts of structure and agency, identity and subjectivity, power and reflexivity are linked and although in the following chapter, I separate them out to discuss each in relation to complexity, I will also demonstrate some of the links between them. All of these ideas have been re-considered and developed in light of post-structural and postmodern thought, and it is possible to relate such lines of thinking to the complexity thinking perspective employed in this work. Complexity can be characterised as relational, fluid, dynamic, multiple, recursive and unpredictable: holding these descriptors in mind, one can see how a complexity perspective might tie in with a relational understanding of power such as that suggested by Foucault (Popkewitz and Brennan, 1998), or a recursive and unpredictable understanding of the relation between emergent structure and relational agency. Similarly we can consider multiplicity and recursion in identity and subjectivity drawing on feminist writing, in which the open-ended nature of a temporal framework that moves away from Cartesian thought is crucial in relating concepts of stability and change in the identities of people and systems. Although there is insufficient space in a single thesis to examine all of these ideas in depth, I consider here aspects of a complexity thinking approach to these concepts that will be of use in analysing a case study of curriculum change. Alongside these

ideas, the conceptualisation of relational and organisational emergence that characterises complexity theory breaks down the difference between individual human and other 'systems that learn', thus developing a framework that allows groups of individuals (or relational groupings which include the material world) to be agentic, to learn, to have an identity and to relate to others at a range of scales. This element of complexity theory also has the capacity to treat other social systems and the non-human environment as the 'environment' for a given complex system. Complexity theory thus forms a particular lens with which to view social science concepts that focuses more on the relational and the dynamic than on the essential and the static⁹. However, the question of how complexity theory is then able to manage some of the above ideas that are regularly conceptualised as 'uniquely human' is open to question, if the barrier between the human and non-human is broken down. The following discussion attempts to explore concepts of identity, agency and reflexivity under a complexity theoretical umbrella that not only allows but embraces the notion that non-human life is part of the complex world. Rather than suggesting that complexity theory breaks down and must of necessity apply differently to the human and the non-human, we can instead consider that elements of human consciousness such as agency and identity, whilst perhaps uniquely human, are also emergent phenomena. Recalling the tenet of complexity that one must examine each level of organisational emergence at the level at which it emerges, perhaps a resolution to this question is to accept that agency, identity and reflexivity can be considered at the level of the individual human, or at levels of collective action of humans. This entails accepting that these are emergent phenomena and can legitimately be analysed using a 'complexity' lens or framework whilst maintaining awareness that these notions cannot be universally applied to all levels of emergence. However, it also entails an acceptance that interaction between the social and material world is part and parcel of the system from which 'human' phenomena such as agency can arise, and thus the material cannot be ignored. This 'new materialism' is an area of current and expanding interest (Coole and Frost, 2010). Such an approach necessitates researcher reflexivity in analysis of emergent phenomena, to take care in considering whether particular ideas are appropriate to use at particular 'levels of

⁹ This is one of the arguments for relating complexity theory to postmodern theories, since modernism can be associated with essentialist rather than relational understandings of the world (CAHOONE, L. E. (Ed.) (2003) *From Modernism to Postmodernism: An Anthology*, Oxford, Blackwell.)

organisation' or in relation to particular emergent phenomena¹⁰. At the same time as being aware of the need for ideas and tools that allow analysis at an appropriate level of emergence, one potential advantage of a complexity perspective is that even whilst maintaining such awareness, complexity theory pays attention to the embodied history of the emergent phenomena. In this way, for example, there is not a clear separation between mind and body. I shall return to and develop this argument in greater depth throughout this chapter.

In this chapter, then, I will argue that a complexity theoretical framework can offer a means with which to think about some crucial ideas in social science (and therefore a means with which to guide the analysis of this particular case) in different and hopefully productive ways. It is not possible within this piece of work to discuss, in depth, the relevant social science literature in relation to agency, identity, power and reflexivity, so the following discussion will assume some familiarity with these key concepts. For each concept, I briefly discuss some of the background to these ideas, their relationship to educational research, to each other, and to the complexity theoretical framework. In the initial part of the chapter I consider recent work in relation to teacher agency, set against the background of the agency/structure debate, and this concept is considered in greater depth than the others in order to foreground the arguments from complexity theory which are then employed in parallel fashion to the other, related key concepts under discussion. However, wherever there is a question of agency, there must also be questions of identity, subjectivity, power and ethics. It has been suggested by some authors that one of the limitations or critiques of complexity theory is that it is relatively silent on these crucial issues (Fenwick, 2009a, Morrison, 2005). This chapter will touch on these critiques¹¹, drawing on the work of poststructural and feminist thinkers, amongst others, to develop a complexity-informed analysis of the developing curriculum in this case. The relationship between complexity theory and some of these ideas have been explored elsewhere (e.g. Morrison, 2005, Olssen, 2008): the following discussion therefore builds on this work in light of the particular theoretical framework outlined in chapter 2. In the final part of the chapter, I shall begin to

¹⁰ This argument will be returned to and discussed in greater depth in relation to its implications for research methodology in chapter 4

¹¹ These critiques will also be considered in greater depth in chapter 4, in relation to ethics in a complex methodology.

consider how a complexity thinking approach to these concepts might 'act' in this particular research case.

3.2 Agency

In previous chapters, I have described how complexity theory can be viewed in line with post-modern and poststructural discourses (see Cilliers, 1998). Continuing with this line of complexity thinking, in this section I consider ways in which the complexity theory framework elucidated in chapter 2 enables a particular conceptualisation of the notion of agency and the structure/agency question. I begin with a discussion of structure/agency, and consider briefly some of the ways in which theorists have approached it. I also draw out some particular theorising of agency in temporal and relational ways that are of particular relevance in relation to complexity theory, and discuss some previous work that has attempted to compare complexity theory with other social and cultural theories. I conclude the section by summarising the complexity-informed view of agency that will be taken forward in this thesis.

In social theory, it is possible to focus research and analysis on a small scale, at the level of the individual member of society or at the level of small groups of individuals. It is also important in social research to examine society at the level of larger scale social structures, such as government or the market. Each of these scales of theory are able to contribute to our understanding of social lives, worlds and practices, but it is the *relationship* between them that various thinkers have sought to theorise. The interaction between the individual and the social structure and cultural environment in which they are located, and the extent to which structure determines the capacity for individual action, is often referred to as the agency-structure question in Europe, whereas in North America the micro-macro debate is the preferred frame (Goulart and Roth, 2010). Agency is commonly defined as 'the capacity for autonomous social action' or the ability to operate independently of determining social structure' (see Calhoun, 2002, cited in Biesta and Tedder, 2007). The workings of the agency/structure dialectic (or the way in which structure influences agency or vice versa, and which is the more powerful lever in society) has been the subject of numerous theoretical works. Giddens' Structuration theory (Giddens, 1979, Giddens, 1984), Bourdieu's Habitus (Bourdieu, 1977), Archer's Critical Realism (Archer, 2003), Latour and Law's Actor-Network theory (Law and Hassard, 1999), Engestrom's Activity theory (Engestrom et al.,

1999) and Lave & Wenger's notion of Communities of Practice (Lave and Wenger, 1991), among others, have attempted to formulate social and cultural theories which resolve the issue of the relationship between individual and social phenomena. Clearly, it is not within the scope of this chapter to provide background on this broad range of theoretical approaches in relation to complexity theory. I therefore give a brief outline of the major features of the structure/agency|macro/micro¹² question and related theories and focus on bringing ideas from complexity theory into the debate. This is important because the relationship between individuals and the groups of which they are part is enormously relevant for the subject of this thesis, as consideration of the influence of both the individual agents in the school, the school structures, and the wider structure of the national curriculum and national accountability regimes will all be important and need to be considered within the operational theoretical framework developed for the study. Complexity theory, and in particular the notion of relational emergence as outlined in the previous section, offers an alternative way of approaching this relationship, and a number of authors have made this argument in relation to the work of the social theorists mentioned above (Fenwick, 2010c, Walby, 2007, Morrison, 2005, McMurtry, 2006). In the following, I consider how relational and temporal emergence and complexity reduction enable a particular, complexivist approach to the concept of agency and how it relates to structure.

Empirically, there is a tendency for some researchers to concentrate on either agency or structure within their work, depending on the scale on which they are focussing, without being too concerned about the relationship between them except in a theoretical sense, reflecting the essentialised dualism between agency and structure within the discourse (Fuchs, 2001). Theories of the structure/agency relationship have tended to focus on the interactions by which agency creates structure, and structure mediates agency. For

¹² During the rest of this discussion, and for reasons of simplicity, I use the terms structure and agency to frame the problem, rather than the alternative macro-/micro- that are commonly used in the North American literature. There are differences between the two perspectives which suggest that the agency/structure framing is more relevant for discussion in relation to complexity theory. In particular, the micro/macro framing tends to a more behaviourist and hierarchical orientation, whereas structure/agency consider the agent as a 'conscious, creative actor' embedded within a 'historical, dynamic' framework RITZER, G. & GOODMAN, D. J. (2004) *Sociological Theory*, McGraw Hill.

example, Giddens' structuration theory considers the two to be mutually constitutive, so it is impossible to have agency without structure and vice versa. As Giddens puts it,

The concept of structuration involves that of the duality of structure, which relates to the fundamentally recursive character of social life, and expresses the mutual dependence of structure and agency. (Giddens, 1979 p. 69.)

Giddens takes duality of structure to mean that structure is both the medium and the outcome of the practices that make up social systems, thus serving a dual role as both a context for action and an outcome of those actions. He argues that this means that structuration theory is not concerned with differentiating between statics and dynamics – an important point in the context of complexity theory that I will return to later. In structuration theory, Giddens is conceptualising structure as both enabling and constraining, rather than simply being a force for constraint of agency and freedom: 'Structure thus is not to be conceptualised as a barrier to action, but as essentially involved in its production' (Giddens, 1979 p. 70). So, in Giddens' structuration theory, the actor (the subject) and society (the object) are both simultaneously in/formed by structure, 'but in neither case exhaustively: because of the significance of unintended consequences of action, and because of unacknowledged conditions of action' (Giddens, 1979 p.70). Hence, the conceptualisation of structuration theory allows for both the impact of the past on the present while at the same time the present may react back against the past, as rules and resources of structure are used by actors as they interact with others, whilst at the same time these rules and resources are reconstituted through the interaction. For Giddens, this relation is crucial for social theory, as it involves a dialectic of presence and absence in space and time, which I understand to mean that structure, through its dual role, mediates between the actor and the wider social system even while the broader social structures are 'absent' in the sense that they are not explicitly drawn on in the inter/action. Structuration theory, therefore, is an attempt to shift the discourse away from *either* freedom of agents to act in spite of structural constraints *or* agency constrained by structure. Giddens highlights the way in which structure enables agency, and agency creates structure, with the relationship between the two being fundamental.

This focus on the interaction and mutual constitution of structure and agency in structuration theory resonates with the notion of 'enabling constraints' in complexity theory

(see e.g. Davis and Sumara, 2006). The concept of 'enabling constraints' in relation to agency/structure will be useful to explore within this case study. Although the notion of enabling constraints sounds like a contradiction in terms, Davis and Sumara argue that the existence of enabling constraints is essential to foster emergence, which in this context implies (in a similar argument to Giddens') that both structure *and* agency are necessary in order to generate change in social systems:

Enabling constraints...refers to the structural conditions that help to determine the balance between sources of coherence that allow a collective to maintain a focus of purpose/identity and sources of disruption and randomness that compel the collective to constantly adjust and adapt...Some constraints are dictated by context, others by the structures of unities, still others through co-implicated action of agents and settings. (Davis and Sumara, 2006 p. 147.)

This notion of the need for *both* coherence *and* randomness is reminiscent of the need for *both* a 'constraining' structure and the action of free agency in structuration theory. However, the difference between the two perspectives is that for Davis and Sumara, enabling constraints are necessary in order for emergence to take place, meaning that the interactions within a system are necessary for something new to be produced. This contrasts with Giddens' perception that structuration is not *necessarily* static or dynamic. This point was highlighted by Morrison (2005) as a key distinction between a complexity perspective and those of other social theories. He notes some similarities between structuration theory, Bourdieu's concept of habitus, and a complexity theory perspective on the structure/agency question, with particular focus on the way in which all three theories conceptualise social change. However, he argues that complexity theory goes further in this regard than the others, since it is essentially a dynamic theory in which the conceptualisation of open, emergent systems moves beyond mechanisms of interaction between structure and agency as mechanisms of social reproduction. Instead, complexity theory focuses on the relationships between structure and agency within a complex dynamic system/environment acting to produce newly emergent social systems. Although not expressed in the language of complexity, this resonates with the conceptualisation of the structure/agency problem in the mutual creation of a science curriculum described by Goulart and Roth, where they found that:

[n]either agency nor structure can provide a suitable account of what happens [in the co-construction of the science curriculum], but in and from the tension-laden

agency/structure unit, new structure (e.g. curriculum) emerges in indeterminate ways (Goulart and Roth, 2010)

The discussion of agency/structure thus far in relation to complexity has focussed on general ideas in complexity theory, and it can be seen that all three elements of the theoretical framework set up in chapter 2 are relevant for thinking about these concepts. Relational emergence is one way of thinking about the social structures that emerge as a result of interactions between agents, and between systems and their environments (or other complex systems). The emergent structure, or complex order, is more than simply a way of explaining the particular interactions between the agents in the system, but is something new in itself. However, although this emergent structure may act to ‘constrain’ the subsequent actions of agents in the complex system (which may appear as a form of complexity reduction), this feedback may foster new possibilities for agency or action that were not possible prior to emergence of the new structure, thus allowing the potential for further emergence. The emergent structure may act as an ‘enabling constraint’ in a process of mechanistic change and temporal emergence – social production rather than social reproduction. The three concepts in the framework therefore interact in considering the relationship between agency and structure from a complex theoretical framework. For a particular illustration of this interaction using a concrete educational example from my MSc dissertation work (Hetherington, 2007), please see Box 2.

The following example took place during my first attempt at conducting educational research. The class were a mixed gender, mixed ability Year 9 group in a comprehensive school in the city suburbs. I intended to ask the students to undertake three tasks to try to find out their ideas about the Earth and the environment. I approached the activity design with the idea in the back of my mind that I wanted to see how students linked ideas in the biosphere, atmosphere, hydrosphere, geosphere and so on. I asked them to complete a short questionnaire, create a concept map and draw a picture to represent ‘what happens on Planet Earth’. Having deliberately kept the task relatively vague because I wanted to know what links they might make themselves, I found that instead, the task went in completely unexpected directions. Although I had asked the students to work individually, I didn’t ask them to work in silence, and I found when I came to analyse their drawings and maps that they could be grouped according to who was seated close to who. I also found that the task had been influenced in an entirely new direction after a student asked me, in a voice that could be heard by many others in the room ‘What happens on Earth...do you mean like, war and stuff?’ I answered, “It is up to you – whatever you think” and was amazed to find the majority of the pictures handed in to me included images of war. This small interaction had created a new structure for the task in the minds of the class. This example can be analysed in terms of the three interacting elements of the theoretical framework. Firstly, the class exhibited a spatially emergent organisational structure, governed in part by the places they were sitting in the room, but also by their own choices over who spoke to whom. The structure of the collectives in the class could be traced through similarities in the concept maps they produced. The class as a whole acted as a collective structure in the way it adapted to me in changing the way they understood the task – the task in itself emerged as a result of the interactions in the class. In this way, one can see the concept of complexity reduction at work, in the way the emergent task structure constrained the results of the task produced by the individuals, even when my response to the question did not deliberately close the task down. Finally, temporal emergence can be seen in the way in which the products of the activity were nowhere near what I could have predicted based on the way in which I set up the task at the beginning. Although the images and concept maps produced by the students demonstrate or embody the trajectory that brought them to that point, they are temporally emergent in the sense that they were unpredictable and not determined by what went before, and produced under circumstances that were outside the norm for their classroom environment – they were working in far-from-equilibrium conditions.

Box 2: Example of agency/structure in complex terms.

The discussion thus far has considered the relationship between agency and structure, arguing that a complexity framework emphasises that the interaction between agency and structure is dynamic, and that it can be seen to be occurring at a range of scales depending on the emergent level of complex organisation on which the focus is placed. This perspective supports the argument drawn out by Fuchs (2001), who points out that a dualist separation of the world into the micro and macro levels as ‘opposite natural kinds’ is unhelpful, as it leads to either an overemphasis on individualised notions of agency or an over-socialised macro view. Instead, he suggests that seeing agency and structure as *relative* and existing along a continuum through which ‘things social move over time’ is a more helpful approach (Fuchs, 2001 p. 26). From a complexity perspective, agency cannot be characterised as a property of a particular individual – in part because the ‘individual’ as a bounded living system is dependent on the ‘level’ of complexity one is working with – but also because in complexity theory, emergence (such as novel and unpredictable actions of agents) occurs through *interactions*. What counts as ‘agent’ and what counts as ‘structure’ is therefore a relatively fluid concept within a complexity frame, mirroring Fuchs’ relative continuum. That is not to say that an individual human is not an important ‘level’ to examine, and in this thesis, agency enacted by individuals, alongside agency enacted by groups and in interaction with different levels of structure, are all important. I therefore now turn to an examination of a complex understanding of agency in greater depth.

Agency is often talked about as a possession: something that a person has and can use, but that can be taken away from them by the action of others. This is similar to the way in which power is sometimes understood as a possession that is used for domination, and that can be overthrown so that dominated subjects can free themselves. Foucault critiqued this notion of power, and the related belief that those who possess power can wield it over subjects who do not have agency (Youngblood-Jackson, 2012). Foucault instead constructed a notion of power that is both *relational* and *productive* (Popkewitz and Brennan, 1998). Such a relational understanding of power can be linked to a relational understanding of agency, where in Foucault’s work agency is understood as an aspect of power relations – so rather than agency relating to action within structural constraints, it becomes action within relations of power that themselves *form* structure through processes that change relations, support in which relations intersect, and strategies in which power is embodied in social

practices. A Foucauldian reading of agency therefore moves from understanding agency as a possession to thinking about agency as something that is *enacted within a relationship*. This kind of approach to agency was conceptualised as ‘ecological agency’ by Biesta and Tedder (2007) in relation to lifelong learning, and, following them, has been adopted by Priestley et al. (Priestley et al., 2012, Wallace and Priestley, 2012, Priestley, 2011) in their recent work exploring teacher agency in relation to curriculum change in Scotland. In this framing agency, rather than ‘residing in individuals as a property or capacity, becomes construed in part as an effect of the ecological conditions in which it is enacted – in other words, agency is positioned as a relational effect’ (Priestley et al., 2012 p. 196). Such a relational or ecological understanding of agency is appropriate from the perspective of complexity theory, and can be related more closely to the concepts of relational emergence and complexity reduction than an understanding of agency as a quality that can be owned, transferred or taken, because both emergence and complexity reduction are processes that arise through the interactions between elements within a system. Priestley’s work illustrates the relevance and use of a relational approach to agency in analysing teacher action in a changing curriculum environment, which suggests that this will be a helpful notion to take forward in this research. However, he also recognises that a limitation of the ecological notion employed in his work, and by Biesta and Tedder, has an ‘individualistic bias’ with a tendency to focus on the agency of individual teachers. Both sets of authors recognise that a notion of collective agency is also important. A concept of agency of collectives or assemblages has been recognised in Actor-Network theory (Fenwick and Edwards, 2010), which is an alternate framework that can be related to a complexity-theoretical perspective (Fenwick, 2010b). This perspective also recognises the importance of interaction between the social and material world, with the potential for agency to be enacted in interaction with the material environment. Accepting the importance of the relationship between the material and the social world has also become an important concept in recent feminist theory, for example in the *agential realism* of Karen Barad (2007). In the context of this research, the agency that is enacted in teachers’ and students’ interactions with curriculum *materials* and with classroom artefacts could be of similar interest in exploring emergence and complexity reduction during curriculum change alongside teachers’ and students’ agentic action in relation to each other.

Thus far, the argument for a relational understanding of agency follows those in other works, which raises the question of what complexity adds or does differently? Earlier, I discussed Morrison's argument in relation to structuration theory and Bourdieu, that the *dynamic* element fundamental to complexity is the aspect which is the difference that makes a difference. This links to the temporal aspect of emergence outlined in chapter 2, which is a further crucial way in which the concept of agency must be explored within a complexity framing.

The temporality of agency is an important element in the work of Emirbayer and Mische (1998), who argued that agency should be understood as 'a temporally embedded process of social engagement': that 'the agentic dimension of social action can only be captured in its full complexity if it is analytically situated within the flow of time' and that 'the structural contexts of action are themselves temporal as well as relational' (Emirbayer and Mische, 1998 p. 963). Drawing on the work of George Herbert Mead, who is an influential figure for many complexity theorists, they use Mead's notion of 'sociality', in which humans are situated in multiple temporally evolving relational contexts, to develop their concept of agency. In Mead's work, sociality contributes to the development of reflective consciousness on the part of actors who are 'active respondents in nested, overlapping systems' in which past, present and future are continually re-figured. Emirbayer and Mische build on Mead's work to define agency as:

The temporally constructed engagement by actors of different structural environments—the temporal-relational contexts of action—which, through the interplay of habit, imagination, and judgment, both reproduces and transforms those structures in interactive response to the problems posed by changing historical situations (Emirbayer and Mische, 1998 p. 970)

This leads them to consider agency in a multi-dimensional sense, which they call a 'chordal triad' of interwoven elements, each of which are important parts in any enactment of agency but in any given act, the relative importance of these different elements can vary. The three chordal elements of agency are given as 'iterational', 'projective', and 'practical-evaluative', which relate to influences from the past, orientations to the future, and enactment within the present respectively. The iterational element of agency relates to 'the selective reactivation by actors of past patterns of thought and action...helping to sustain identities, interactions and institutions through time'. The projective element of agency is

defined as ‘the imaginative generation by actors of possible future trajectories of action, in which received structures of thought and action may be creatively reconfigured in relation to actors’ hopes, fears, and desires for the future’. Finally, the practical-evaluative element is seen as ‘the capacity of actors to make practical and normative judgments among alternative possible trajectories of action, in response to the emerging demands, dilemmas, and ambiguities of presently evolving situations’ (all three quotes defining dimensions from Emirbayer and Mische, 1998 p. 971). They argue that this multi-dimensional construction of agency is more reflective of reality than the uni-dimensional constructs that they suggest are limitations in much work on agency. These include orientations which see agency as dominantly to do with judgement and deliberation such as in feminist theory, or those that are mainly focussed on agency as goal-seeking and purposivity.

The view of agency put forward by Emirbayer and Mische suggests that, rather than seeing agency and structure at opposite ends of a spectrum in which agency constitutes freedom to act against a constraining structure, agency acts to sustain *and* change the temporal-relational contexts of action (structures, or broader levels of system in the language of complexity theory). This is because agency does not simply equate with freedom to act, but is influenced by experiences of the past (like Bourdieu’s habitus) and orientations towards the future. It is important to remember that within this temporal view of agency, enactments of agency can equally involve acting to maintain a status quo within a dynamic and changing temporal-relational context (Biesta and Tedder, 2007). Agency is not necessarily related to action against repressive system constraints, where the structure, environment or system is the status quo.

The dynamic and temporal nature of the Emirbayer and Mische conceptualisation of agency is of interest in examining this concept from the framework of complexity. Earlier, I argued that a complexity perspective on agency might suggest a relational conception of agency as enacted in interactions within and between nested levels of organisation. I also suggested that the idea of relational emergence and complexity reduction can be helpful in considering agency in this relational sense. Emirbayer and Mische’s argument for a temporal element to agency in addition to the relational add a further layer that ties to a complexity perspective (which is perhaps not surprising given the joint antecedents in Mead’s work). This is practically helpful, as their insight into agency within dynamic and changing,

interwoven temporal-relational contexts allows us to consider action by different levels of a system, in changing contexts. However, the idea of relational agency also leads us to a question of action in an undetermined temporal context. This is seen in Emirbayer and Mische's work, but can also be drawn out from arguments based on Foucault's ideas of relational power. Such an argument was formulated by Picard (2010), who suggests that,

...a notion of relational agency is implicit within Foucault's descriptions of power relations. That power is precisely a relationship means that it is always possible to act in other ways and, therefore, an omnipresent power does not entail stasis. Rather, agency is refigured as an aspect of power relations. Foucault pointed out that there are always risks imposed by power relations because the result of any action can never be guaranteed. Yet, it is because there are risks that I argue a relational agency is generated. (Picard, 2010 p. 5)

This shows a clear link between a relational understanding of agency and power and the concept of temporal emergence, suggesting that as a result of the relational nature of power, agentic action must always entail some unpredictability. Such indeterminism reflects the unpredictable dynamic of complexity thinking. The temporal nature of agency in Emirbayer and Mische's work, although acknowledging that imagined futures can be uncertain and indeterminate, does rely on decision-making based on an imagined, and therefore potentially imaginable, future.

Using the complexity framework outlined in chapter 2, it can be argued that during periods of mechanistic change (at equilibrium), agentic action is likely to be more straightforward as an imagined future is possible. However, given that the enactment of agency is 'always located between past and future' – in other words, it is always at the leading edge of emergence if agency is enacted in far-from-equilibrium conditions – then the notion of strong emergence in complexity theory requires further thought about agency in a temporal-relational context which is by definition 'not yet possible'. This leads us to question how agency is possible within a framework of 'strong emergence', which takes us beyond the work of Emirbayer and Mische. Deborah Osberg's work can help us, here, as we may draw parallels with her discussions of 'non-normative normativity', politics and responsibility towards an uncertain future using complexity theory and strong emergence. She raises the question of 'how it is possible to adopt an affirmative orientation to the future' when that future is, in complex terms, *undecidable* (Osberg, 2010a). This is precisely the problem for understanding agency as a temporal-relational activity in far-from-

equilibrium contexts. Osberg considers Land and Jarman's solution to this problem, which is 'to act in a way that we think will meet the needs of the imagined future' (Osberg, 2010, p. 158). This view is parallel to the projective orientation of agency in Emirbayer and Mische's work. However, Osberg argues that this fails to take account of the ethical and political problem of who decides which imagined future society should be oriented towards. If we take agency to be solely the focus of individual human beings, this limitation dissolves, as each individual can be viewed as enacting agency in relation to their imagined futures, in the interests of themselves or others. However, given the preceding argument that agency is relational and can apply to collectives as well as individuals, this ethical and political problem remains. Any action that is taken is a form of complexity reduction, as it 'chooses' to enact one possible future and closes down others. Osberg argues that the logic of strong emergence resists this by arguing for a different way of envisioning the future. Instead of making choices (enacting agency) by imagining a future based on what has worked in the past, the logic of emergence (which is understood as 'the experience and experiment of the possibility of the impossible') suggests that it is important to orient towards the future in a way that moves beyond making choices based on an imagined future and towards using the past to invent new possibilities through experimentation and invention. Applying this to Emirbayer and Mische's conceptualisation of agency, the iterative dimension of agency remains important, but is used to inform both the practical-evaluative aspect and the projective aspect of agency in a way that asks us to experiment with the past and present to create something new. Essentially, the notion of strong emergence adds an element to this understanding of agency, which is that an *inventional* or *creative* dimension of agency is as important as a projective dimension within an indeterminate and unpredictable future. A creative dimension to agency exists in both this temporal sense, and in the relational sense in that agency can act to *create* emergent *structure* (or higher levels of organisation, environment, or temporal-relational context) as well as emergent *futures*.

The temporal element of agentic action can be linked to notions of power, subjectivity and reflexivity, if they are understood using the same 'complexity thinking' approach. In the preceding discussion, I have touched on Foucauldian notions of power within the argument, and I will expand on these ideas in the rest of this chapter. In particular, the notion of reflexivity as a crucial aspect of enactment of agency within temporal-relational contexts

(linked to the 'evaluative' in the practical-evaluative aspect of agency) is important and I have not expanded upon this in the discussion thus far. This is central to the argument made by Margaret Archer in relation to mediation between agency and structure/culture and I draw on Archer's ideas in the next section of this chapter to develop a 'complexity thinking' understanding of reflexivity.

3.3 Reflexivity

Reflexivity is a crucial concept in relation to the interaction between agency and structure, having been used by both Bourdieu and Archer in their respective theorisations of this relationship. For example, Archer summarises the central question in the discussion of the structure/agency dialectic as, '*how* does structure influence agents?' She argues that a consensus has been reached that it is not through a process of social determinism, and postulates that the mechanism by which structure influences agency is through 'the properties and powers of agents themselves' via a process of personal reflexivity (Archer, 2003 p. 1). Archer develops the concept of the 'internal conversation', through which agents reflect on their social circumstances. This notion relates to the idea of identity, which Archer sees as 'their individual configuration of concerns' (Archer, 2003 p. 30), where agents seek to realise things in society that are particularly important to them. In this way, agential reflexivity mediates the way in which agents respond to particular social circumstances and structures. This framing allows both agents and social structures to have causative power through the interaction between sociocultural properties and agential reflexivity.

In this account, we can see the way that reflexivity, where agents reflect on and consider their personal goals in relation to their social structures, forms a mechanism by which agency and structure work together. In elaborating these concepts in greater depth than it is possible to do here, Archer brings together concepts of power and identity in relation to the reflexive internal conversation by which structure and agency are mediated. This is a clear example of the way in which all of these concepts are viewed as important in the study of a social system, and has for example been employed alongside an ecological concept of teacher agency, within a study of curriculum change in Scotland (Priestley et al., 2012). This suggests the utility of these ideas for the particular project undertaken here. For Archer, structure, culture and agent all have power to act on the other elements through their interaction. This, I believe, leads to a relational understanding of power, which I will discuss

in more depth shortly. To return to reflexivity, however, I now explore how such a notion of reflexive thought relates to a framework of emergence and complexity reduction.

A literature search for complexity theory and reflexivity or reflection yields few returns, with many of these being articles relating ways in which complexity theory has been used to aid reflection on particular forms of practice (Preskill, 2009, Southworth, 2004, Ciccone et al., 2008) and research (Phelps and Hase, 2002), or theoretical reflections on complexity theory (Kuhn, 2008, Alhadeff-Jones, 2009). For many researchers working in complexity and education, the relationship between complexity theory and postmodern thought suggests methodologies that lend themselves to multiplicity, open-endedness, and a reflexive approach to research are in keeping with complexity thinking (see the methodology chapter for more in depth discussion). However, the relationship between emergence, complexity reduction and reflexivity in social action is not explicitly discussed in the literature.

In considering reflexivity in relation to the structure/agency question, both relational and temporal conceptions of emergence are useful. Relational emergence helps us in re-thinking the structure and the individual agents as interacting parts of the complex system. Agents as individual humans can be seen as a particular level of emergent organisation. Similarly, social structures can be seen as emerging from the interactions of individuals, and in complexity theory, these higher levels of social organisation can also be seen as agentic. As already discussed, in relational emergence the different levels of organisation can exist simultaneously and interact with each other. Applying Archer's argument to relational emergence, reflexivity by agents at a particular level of organisation *is the means* by which the different emergent levels of organisation can interact. A key difference is that in a complexity framework, agency and reflexivity can be applied to collectives as well as to individual human beings. The ways in which complexity framings break down the separation between human and non-human, or mind and body, has been used by Fenwick to argue that complexity theory affords an alternative conception to the dominant 'mind/body' separation in theorisations of experiential learning through a notion of 'co-emergence' (Fenwick, 2004), which has implications for the action of reflexivity within a complex system. 'Co-emergence' of the environment and the learner (or system) highlights that in and between complex systems, learning and development takes place at micro *and* macro levels, with interactions between people, groups, the environment, resources and materials

all weaving together to contribute to emergence, which relates closely to the preceding discussion of agency. In relation to reflection (in the context of practice-based learning), Fenwick argues that,

most of this complex joint action leaks out of individual attempts to control behaviour through critical reflection. And yet, individual reconstructions of events too often focus on the learning figure and ignore the complex interactions as 'background'. Complexity theory thus interrupts the natural tendency to seek clear lines between figures and grounds, and focuses on the relationships binding humans and non-humans (persons, material objects, mediating tools, environments, ideas) together in multiple fluctuations in complex systems. (Fenwick, 2004 p. 51)

Reflexivity in a complex framework, then, moves beyond thinking about the reflective action of agents within a structure, and it becomes necessary to acknowledge that reflexivity must be *relational* rather than focussed on a particular individual with their context as background, and at the same time reflexivity is a process by which emergence of unpredictable phenomena, actions or learning may occur – even when not anticipated by the 'figure', agent or system on which the reflection may be focussed. Reflexivity is therefore an important concept in relation to analysis of curriculum change, because of the role reflexivity plays in both mechanistic and emergent change. In the analysis of this case study, it will be helpful to explore how relational reflexivity is used by individuals and collectives in taking forward the changing curriculum.

Since reflexivity is situated in time – reflecting on the past or present to orient action toward the future – temporal emergence is also important. Here, I employ the logic articulated earlier in relation to complexity reduction, as the question over the position of reflexivity within an open-ended and unpredictable space is a difficult one. If reflexivity is about orienting action to achieve particular social goals (as in Archer's work), then this understanding of reflexivity is clearly located in an iterative rather than an emergent framing. And yet, we know that people and groups undertake reflexive social action in complex systems. This question – how can one think reflexively in relation to an open-ended, indeterminate or uncertain future? – is another form of the problem of projective agency discussed in section 3.2. The suggestion that tentative experimentation with the future through a reflexive consideration of past and present (drawing on Osberg, 2010), allowed the development of a creative dimension in the enactment of agency. Relating this to the notion of reflexivity, an understanding of reflexivity rooted in the conceptualisation of

temporal emergence would reflect on the past and present, not in order to allow the agent to act to move towards a particular goal, but instead to experiment with previously unimagined/unimaginable possibilities – to change the ‘rules of the game’. Building on the logic of emergence to develop a notion of creativity as a dimension of agency, we can now view reflexivity as part of the process of enactment of creative agency.

It seems, then, that reflexivity can be thought about in three different ways, employing the three different strands of the theoretical framework for this work. It can refer to a process undertaken by individuals or groups by which they reflect on the ‘enabling constraints’ in relation to the particular dynamic context of their complex system and act in particular ways as a result (relational reflexivity). It can refer to reflexive thought about the past and present (which may include a relational/contextual element) which reduces options for action through a form of complexity reduction that may include goal-oriented thinking. Such ‘complexity-reduced reflexivity’ does not necessarily mean that something unexpected might not emerge, but perhaps this form of reflexive thinking might pertain most commonly to periods I identified earlier as periods of mechanistic change, and be linked to the ‘projective’ and ‘evaluative’ dimensions of agency discussed earlier. Finally, a ‘temporally emergent’ style of reflexive thinking might refer to reflection on past, present and context with an orientation to the future that ‘uses the lessons of the past to invent something radically new’ (Osberg, 2010a p. 164), in contrast to using lessons of the past to modify actions in order to achieve a particular goal. This can be related to a creative dimension of agency. Separating reflexivity in these three ways, however, only highlights the necessity in using this complexity-inspired framework of maintaining an understanding of reflexivity as *relational* rather than situated ‘in an individual’s mind’. It may be the case that the participants in the study maintain a different perspective on reflexivity, which, although likely to be viewed within this framework as an example of ‘complexity-reduced reflexivity’, means that a crucial element of analysis using this frame will be an awareness of the points at which participants are using concepts differently, highlighting this difference and using this to re-think both the framework and the case.

3.4 Power

Similar arguments to those outlined above can be adopted in relation to the concept of Power in a complexity framework¹³. It has been argued that complexity theory is 'relatively silent on issues of power' (Morrison, 2005 p.321) since in complexity theory, power is hidden in the notion of adaptability for survival, and it is possible to interpret complexity theory in such a way as to conceive it as politically 'neutral'. Fenwick also suggests that complexity theory 'lacks theoretical constructs that can address power, agency and responsibility' (Fenwick, 2010a p. 93). This idea rests on the perception that complex systems develop, evolve, adapt and survive through natural mechanisms that exist without moral imperatives or ethical ideologies. Linking complexity thinking with postmodernism is a further element in such an apolitical framing of complexity, since postmodernism has been critiqued for its ethical and moral relativism (though this is contended by numerous scholars - see, e.g. Bauman (1993) for discussion). In deriving complexity theory from theories in the natural sciences, the origin of this line of thinking is clear, but the complexity 'turn' in the social sciences also includes argument that complexity thinking affords a particular understanding of relational power, similar to a Foucauldian perspective, and an understanding of ethics that is rooted in relations between beings and the environment rather than a particular objective morality such as might be conferred within a normative moral landscape. The question of whether power can be understood in a complexity sense has been addressed in some work, for example by Gershon (2008) in an exploration of lines of power within a classroom. It is beyond the scope of this work to rehearse these arguments in any depth, but the discussion of agency in the preceding section points to the potential to address issues of power, agency, responsibility, ethics and politics within a complexity frame. Instead, I will focus my discussion on a relational understanding of power linked to the concepts of emergence and complexity reduction.

Rather than understanding power as something that can be held or owned by particular bodies (individuals or groups), in other words, something that exists in finite amounts such that if someone or something has power, someone or something else must not; a relational understanding of power such as that developed by Foucault is more appropriate within a

¹³ Of necessity, the discussion of concepts such as power and reflexivity are brief in relation to the wide-ranging literature available on the subject. Instead, the focus of this discussion remains on a 'complexity thinking' perspective on these topics with only limited background provided.

complexity framework. Foucault understood power as a network of interactions within which humans live, and developed a relational concept of power and agency where power pervades all interactions such that individual subjectivities can only exist within relations of power. As discussed in section 3.2, this argument therefore suggests that agency also exists in relationships rather than an innate 'property' of an individual. This relational thinking about power and agency has been brought together with complexity theory by Picard (2010). Picard argues that complexity theory moves the relationality of power away from the simply human and into the domain of the environment as well: 'Complexity theory makes it clear that human isolation from environments and from nonhumans is impossible; there are no purely social relations of power because complex systems are always both social and ecological' (Picard, 2010 p.7). She goes on to suggest that the corollary of this argument is that, 'The importance of recognizing that power is inherent within every interaction — both social and ecological — is that it shapes those relationships in particular ways. Thus, all relationships within complex systems are necessarily relations of power and, as such, they are never purely ecological' (Picard, 2010 p. 7). This position is precisely the opposite of that which suggests that complexity theory is not a theory which deals with power, arguing as it does that the action of power is not limited to the human or social world.

How does such a relational understanding of power relate to notions of emergence and complexity reduction? What does this mean for the current case study of curriculum change? Following similar arguments to those presented previously in terms of a relational perspective on structure, agency and reflexivity, the key point that can be drawn from the preceding discussion in relation to the current theoretical framework is that temporal emergence, relational emergence and complexity reduction must all be considered in the context of *relationships*, in this case in the context of power relations. Actions of agents or elements within a complex system are influenced (though not determined) by the web of power relations, and this is an important consideration in the relational emergence of organisational structure. Power relations may also be implicit in apparent complexity reduction, where the exercise of power appears to reduce some 'options for action'. The inherent unpredictability arising from the risk induced by action within a web of power relations can be framed as a form of temporal emergence, where 'risky' action moves the

system away from equilibrium and increases the range of 'unimagined possibilities' that may emerge as a result.

To illustrate this briefly with an example, imagine a 'normal' classroom, with a teacher who has planned a lesson on a given topic. It is common to believe that in this situation, the teacher has the 'power' and the students do not – the teacher is able to dictate the curriculum content that will be covered in the lesson, the activities the students will undertake to learn that content, the layout of the room, when and how much it is acceptable for the students to speak. Manke (1997) describes this as a traditional and pervasive view of classroom power, and argues for replacing this view with a notion of power as jointly constructed or relational, founding this notion on Foucault's work. Such a concept of classroom power shifts the perception of power away from something the teacher 'holds' and the students do not, to an *agreement* between participants in the classroom activity about what can be done, and by whom. Such an agreement may be tacit, but it is still a construction of power relations that is developed through the interactions between teachers and students. Looking at the classroom through this lens, we develop a more dynamic, contested and multiple picture of the constant negotiations, shifts and tensions in the classroom relationships. This picture also moves away from a focus on the teacher as the source of all power in the room (with therefore all the responsibility for whether or not learning takes place, and even what is learned) and relationships between students becomes an equally important an element in the web of power relations and therefore in the actions that emerge within the classroom space. A complexity perspective brings the material and environmental into play as part of the system, and we may think about how the presence of curriculum artefacts, or perhaps technologies such as mobile phones might have on the network of power relations in the class. Using a mobile phone might be breaking the rules of the classroom, and could be seen as a risky move on the students' part. If a student can check the teacher's knowledge on her phone, how might that change the equilibrium of power in the class – using the language of complexity, how might this take the system out of equilibrium and foster different emergent possibilities? The concept of temporal emergence can be used to examine the way in which such an action might lead to unpredictable and new responses within the lesson by both teachers and students. Relational emergence might be brought into play as the classroom structure

could shift in response to the introduction of the new technology, creating new 'rules' to organise the classroom in light of the availability of information via a phone. At the same time, one response might be the banning of phones in the class, which would be an example of complexity reduction in response to shifting power relations.

In this framework, then, power is seen in the relationships between elements within a system, and is also something which pervades complex systems, with shifting power relations contributing to emergence or reduction of complexity. This argument develops the previous discussions of structure, agency and reflexivity as fundamentally relational within a complexity framework, and in the final section of this chapter I consider identity, or subjectivity, from a similar relational, complex perspective.

3.5 Identity/Subjectivity

The concept of 'identity' is one that has been used to a great extent in social science and educational research, and is one of those terms where one can assume one knows what it means, but that meaning might be different to different people. In fact, identity is a highly contested construct. Moje and Luke (2009) conducted a literature review of identity in literature research, and found five different metaphors commonly used to conceptualise identity: identity as difference, identity as sense of self (subjectivity), identity as mind or consciousness, identity as narrative and identity as position. Identity is often associated with something stable, inherent to an individual – something that defines them – and this notion of identity as individual or psychological may be associated with modernist styles of thought. More recently this has shifted with the advent of 'subjectivities' in postmodern discourses towards a concept of multiple identities (Weedon, 2004). This shift tends to position identity as something that is 'caught up in (and subject to) the globality of networks and with that their dependences – all of which renders identity inconsequential, episodic and brittle' (Elliott and du Gay, 2009 p. xiii). Others argue that although identity can no longer be seen as something that is inherently individual, instead seeing it as something that develops 'in relation with the social', the notion of identity is still important in understanding the actions of people and groups (Lawler, 2008).

Identity is related to subjectivity and the two terms are often used interchangeably, but as highlighted above, subjectivity is rather more closely defined than identity and is usually used in relation to the 'making of the subject', or how people see themselves. Alongside

subjectivity, identity may be used to mean how others see us, how we identify ourselves through similarity and difference or how we perform our multiple identities in relation to a particular context or social location. It is anticipated that alongside the concepts from social science already discussed, a notion of identity may be necessary in analysing the case, as it may be influential in the changing curriculum depending on teachers' and students' ideas of their own identities in relation to the educational contexts in which they find themselves. Again, a relational conception of identity can be developed using complexity theory and it employed in this work, whilst bearing in mind that the participants may be working with different (and possibly more essentialist) ideas.

Following parallel arguments to those offered in relation to agency, reflexivity and power, I suggest that a relational understanding of identity would be appropriate within a complexity frame. Thus, identity (of a system, which could be an individual or a group) emerges in interaction with other systems and the system environment. We can also argue that the identity of a collective emerges from interactions between the individuals who are part of that collective, and so the collective identity is influenced by (though cannot be reduced to) the relational identity of the actors who make up the collective. The concept of an emergent system identity that is 'greater than the sum of its parts' can be related to performativity of multiple identities (Lawler, 2008), because the identity that is performed in relation to others is dynamic, meaning that in interaction, new identities can emerge. A relational notion of identity also means that the emergent identity of a group is *also* relational and performed in interaction with other systems, and is not an essential property or possession of the collective. Identity is closely related to reflexivity and agency, so arguments rehearsed above relating to the temporality of these concepts are also relevant to identity. If identity is understood as the way in which a 'learning system' (be it an individual or social collective) sees itself in relation to others, it can be related to the concept of embodied history in complexity, so that the present identity embodies the 'identity history' of the system. Identity also has a performative element in the present enaction of identity that is related to both projective and creative orientations to the future. Thus, we can consider identity, like agency, as something that is enacted based on the 'identity we want to be' (projective) or the 'identity we might create' (creative). Again, following the line of argument presented earlier, reflexivity can be seen as playing an important part in the process of enaction of

relational identity. So, we can see that complexity theory implies a focus on the interactions within a system and what emerges as a result of these interactions, which in the context of identity or subjectivity, highlights the way in which an 'identity' is produced and performed *in response to others*. A complexity perspective, with its focus on change, also emphasises *changes* in identity and subjectivity. Using the framework of emergence and complexity reduction, we may consider identity as something that might develop iteratively in a system at equilibrium, related to projective orientations to the future, or change radically – emerge – when the system is taken out of equilibrium and where creative orientations to the future are more likely to be prompted. A concept of identity within a complexity framework will be important in the analysis of the case study because the notion of teacher and student identity is likely to be helpful in considering how teachers and students act and interact with each other in relation to the changing curriculum in the case. How teachers see themselves as teachers, for example, might influence their approach to the changing curriculum and thus their interactions with each other, as teams, and with students. At the same time, this perspective on identity does not see it as fixed but as dynamic and continually 'performed' in the present moment, with the potential for new identities to emerge. It is possible that new identities may emerge as teachers and students interact in ways that are rather different from before due to the changing curriculum environment.

The 'complexity thinking' understanding of identity discussed above recalls a perspective on subjectivity and education that has been used by Osberg and Biesta in their use of the 'logic of emergence' along with the work of Arendt and Foucault to theorise subjectivity and education from an emergentist perspective (Osberg and Biesta, 2008). Subjectivity in this context is seen as continuously changing and is created as it is performed 'in the moment' through actions in relation to others' actions, rather than those actions revealing aspects of a stable or essential identity. In this sense, subjectivity is both relational and emergent. Osberg and Biesta relate this understanding of subjectivity to education through the argument that for education to be truly 'educational', rather than something else – socialisation or qualification within a particular social structure – then it is about the emergence of subjectivity through engagement with difference. Subjectivity may emerge in the 'gap' or 'space of emergence' that is the relation with another (such as the teacher-student relationship), where *through that relation* one is confronted with difference that

takes one out of equilibrium – out of one’s ‘comfort zone’ – and opens previously unimaginable possibilities of what one can make of oneself in response¹⁴. The argument then follows that it is important in education to build difference into the curriculum and into the classroom, to create possibilities for such subjectivity to emerge. Davis and Sumara make a similar argument in their discussion of some necessary conditions for emergence (see section 2.2.2), which include both diversity and redundancy. They argue that there must be sufficient difference for the system to be able to adapt and create something new, but sufficient similarity to enable communication within the elements of the system (Davis and Sumara, 2006).

This perspective on subjectivity in relation to classroom activity focuses most closely on the notion of temporal emergence within the current framework through the use of emergentist logic. However, relational emergence is potentially a helpful conceptual tool in considering where the relations are between elements in a system, and thus where the potential for the emergence of subjectivity might be. Similarly, Osberg and Biesta (2008) highlight ways in which classrooms are arranged so as to minimise difference, and therefore limit the possibilities for emergence of subjectivity through relation with an ‘Other’.

‘However, if plurality is the condition of possibility of education, then this challenges the conventional logic of schooling whereby everything possible is done to reduce the differences between the teacher and those being educated on the one hand, and the differences between the various individuals being educated by the teacher (e.g. in terms of age, gender, ability, interests, etc.) on the other. The idea of a ‘space of emergence’ suggests that difference must be maintained in the classroom. Any reduction of such difference prevents education from taking place.’ (Osberg and Biesta, 2008 p. 324)

Although the term ‘complexity reduction’ is not employed directly in this particular paper, the argument that the reduction of classroom difference as described above is a form of complexity reduction is implied.

Identity and subjectivity then, viewed as relational and emergent within a complex system, may be employed in this framework as important tools in thinking about any social system but also as uniquely important from an educational perspective. This combination of ways

¹⁴ In their writing, the implication is that subjectivity is uniquely human and the suggestion that the relation with the ‘other’ is another person. However, as has been discussed previously, complexity theory also enables us to break down the distinction between human and non-human, and the ‘space of emergence’ may arise between human and non-human also, so long as there is confrontation with difference.

of thinking about identity will be necessary for analysis of the changing curriculum, partly in relation to the change of subject material in the curriculum, and partly in relation to the changing subjectivities of teachers and students in their interaction with the changing curriculum.

3.6 Summary

In this chapter, I have discussed key concepts in social science from the perspective of complexity theory in general and the theoretical framework developed in chapter 2 in particular. The concepts of structure, agency, reflexivity, power and identity were discussed as both *relational* and *temporal*, with particular implications for emergence and complexity reduction as a result of a temporal-relational understanding of these ideas. Relationality between humans, and between humans and non-humans within a complex system is the foundation on which emergence of structure, agency and identity continue, influenced by a pervasive network of power relations and continued process of reflexivity. Power and reflexivity may be conceived of as aiming towards particular goals or objectives and therefore analysable through complexity reduction. However, they may also be conceived of as emergent and contributing to emergence through the invention of something new in response to shifting power relations or in response to reflection on the past. The re-framing of these concepts using a complexity thinking approach therefore informs the particular ways in which the case study can be explored empirically. Different theoretical frameworks enable us to ask different questions about real-world situations and about data (see Youngblood Jackson and Mazzei, 2012). Therefore, complexity theory focuses empirical work on relationality, or interactions, situated within a flow of time. In this thesis, concepts of agency, identity, reflexivity and power, interpreted through a complexity lens as discussed in this chapter, will be used to explore the actions of those engaged within the system to explore a changing curriculum. In this way, the empirical work of this thesis will enable me to consider how the notions developed in the theoretical introduction provided in chapters 1-3 may be used to explore the world and make pragmatic recommendations for research and teaching in a real-world context. At the same time, it is anticipated that the empirical data and analysis will enable me to reconsider and develop the ideas presented in this initial theoretical work.

Chapter 4 - Methodology

4.1 Introduction

In conducting this research, I have chosen to use an approach inspired by 'complexity thinking' to inform both the research problem and as a framework for conducting the research. It is therefore important to begin by discussing how the methodological choices in this research were informed by the complexity theoretical framework. Methodology is a link between the ontology, epistemology and theory informing the research and the practice of conducting that research. As McCall puts it, 'ideally, a methodology is a coherent set of ideas about the philosophy, methods and data that underlie the research process and production of knowledge' (McCall, 2005 p. 1774). Hammersley (2006) highlights that there is a tendency on the part of educational researchers to either focus on 'methodology-as-technique' or 'methodology-as-philosophy'. Whilst acknowledging that philosophy has an important role to play in ensuring a questioning and thoughtful attitude to the assumptions made in conducting research, he suggests that methodology-as-philosophy has limitations if the approach to philosophy is not sufficiently well-grounded in critical analysis of the philosophical ideas. Effectively both McCall and Hammersley are arguing for research that links a well-supported and clear philosophical and theoretical approach with the methodology, methods, data and analysis chosen. Part of my purpose in this chapter, then, is to outline a coherent relationship between the complexity-theoretical framework, the way that framework informs the philosophical basis of the research (its ontological and epistemological assumptions), and the methods used and data collected which underpin the claims to new knowledge I will be making in the interpretation and discussion of the data.

This chapter is therefore divided into two parts. In the first, I offer a general discussion of methodological choices in educational research which is inspired by a complexity approach, relating these to the background discourse of research methods in education before outlining the general approach to research used here. I include consideration of what it means to conduct responsible and responsive ethical research informed by a complexity approach within a changing environment. In part two, I provide details of the research design and methods used in this study, paying particular attention to the tensions experienced in 'designing' this piece of research to be responsive to unpredictable and emergent trajectories during the period of research.

4.2 'Complexity Thinking' Methodology

In the early stages of formulation of this research study, I completed a research methods course providing grounding in conventional educational research methods within both the 'interpretive' and 'scientific'¹⁵ paradigms. This course challenged my ideas about what constituted 'research'. The problems I struggled with related to my concern, stemming from my previous education in the natural sciences, that it was impossible to conduct a true 'experiment' in a classroom setting, and therefore I was dissatisfied with quasi-experimental approaches to research that appeared common within the scientific paradigm. However, at the same time, I remained uncomfortable with some interpretive approaches to research as I found it difficult to engage with what made some of these approaches 'research' rather than some other form of knowledge-creation. I could accept that they could be *creative* and produce new ideas and understandings, but I struggled to find the link to the objective, real world that I saw research as 'finding out about'. As I mentioned in chapter 1, one of the reasons for my attraction to complexity theory was its relationship to science, and so I began to explore complexity theory in education as a framework for my research. As I began to develop the proposed research for the thesis I encountered difficulties in translating the 'scientific' and 'interpretive' paradigms, with their associated methodological commitments, to fit with my tentative thinking about complexity. This confusion was summarised in an entry in my research journal:

I find myself asking: What constitutes quality empirical research from a complexity perspective? What sorts of approaches are consistent with a complex epistemology? How can I navigate a path through the maze of interconnected questions and ideas I continue to struggle with? – basically, what am I going to do? Research Journal, 19/2/09

My concern over research quality and the 'best' methodological approaches to achieve such quality reflected a relatively recent debate in the literature over what constitutes 'good' research in education. In the UK, a number of influential reports critiquing educational research had been published (Tooley, 1998, Hillage, 1998, Hargreaves, 1999), which argued that the research was fragmented, not fit for purpose in relation to recommendations for policy or practice, and lacking in methodological rigour (Pring, 2000a, Evans, 2002). Similar

¹⁵ I use the term 'scientific' for this paradigm throughout the text, because this was the label given in the research methods course to which I refer. It could, however, be argued that this reflects only a limited concept of 'science' that does not reflect developments in scientific thinking in relation to both quantum theory and complexity science.

deficiencies in educational research were also identified in the USA (Swann and Pratt, 1999). In relation to fragmentation, it is argued that education researchers need to ensure that their work is cumulative, grounded in critical and thoughtful understanding of pre-existing work in education and in other disciplinary areas, and that in order to address the critique of fragmentation, educational research needs to show that even where small in scale, it is able to contribute to the generation of new theory that goes beyond the particular research context (Hammersley, 2007). In relation to 'fitness for purpose', there is ongoing and sustained argument over the feasibility and utility of applying notions of evidence-based practice rooted in medicine to education (see e.g. Biesta, 2007, Biesta, 2010b), although I have yet to meet a researcher in education who is not interested in the pragmatic and practical utility of their work. In the thesis as a whole, I hope to illustrate that the complexity-informed approach to the research, though small-scale, is rooted in previous research, able to contribute to theory, and able to offer implications for classroom practice. In this chapter, I am most concerned with the third element of the above critiques of research: methodological rigour, and how this can be achieved within a complexity framework.

Scott (2000) discusses some common fallacies he identifies in educational research. As Evans (2002) argues, although these fallacies are not directly related to research processes and methods, Scott's suggestion that they undermine research quality means that addressing these fallacies is necessary in ensuring the rigour and quality of the research undertaken. Scott argues for a realist approach to educational research as a way to 'avoid the pitfalls' identified: In the following discussion, I consider how a 'complexity thinking' approach to methodology is a reasonable alternative that also has the capacity to address these issues. The fallacies identified by Scott are as follows:

- 1. The epistemic fallacy – ontology and epistemology are conflated so that it is not possible to understand how transitive methods may be used to examine relatively intransitive structures.*
- 2. The fallacy of homogeneity – the characteristic given to a group of people are assumed to apply to individuals within that group*
- 3. The causal fallacy – observed patterns of behaviour are construed as causal configurations*

4. The essentialist fallacy – appearances are frequently conflated with essences and understood as all there is

5. The fallacy of value-free knowledge – knowledge of educational institutions and systems is thought of as value-free. Educational researchers therefore ignore the value-rich dimension of their activities

6. The prospective fallacy – retrospective viewpoints are frequently conflated with prospective viewpoints. Educational researchers may be able to explain what has happened, but this does not mean that they know what will happen.

7. The reductive fallacy – human characteristics and attributes are reduced to variables which cannot be further reduced and which when combined capture the essence of either that human being or the educational activities they are engaged in. This acts to trivialise and distort descriptions of those activities.

8. The deterministic fallacy – frequently educational researchers neglect human intention and creativity in their descriptions of educational activities

9. The fallacy of pragmatism – educational researchers understand research as a practical activity which can be carried on without reference to epistemological and ontological concerns. (Scott, 2000 p. 2)

Due to the philosophical nature of these fallacies, addressing them means paying attention to the philosophical and theoretical underpinnings of the research. I now turn to this, to consider how ‘complexity thinking’ influences the methodological choices and challenges faced in conducting educational research and how my approach addresses Scott’s fallacies.

Complexity theory has been taken up both in educational research and more broadly in social science, but relatively little has been written relating ideas from complexity to the way in which research is conducted, possibly in part because of the breadth of ideas under the complexity ‘umbrella’ discussed in chapter 1. For example, complexity scientists working from a perspective in which non-linear modelling of complex systems is a productive avenue for research will have a different take on research methodology than those viewing complexity from a postmodern or poststructural frame. Finding a ‘complexity’ methodology is not a simple case of identifying some rules or even guidance from previous literature and applying it to this case: It is necessary to take a stance of constant critical engagement with the theoretical framework, research methods, and research skills (Evans 2002). In considering the methodological approach for this work, I have searched for guidance from the available literature explicitly discussing methodology from a complexity stance, from literature reporting on empirical studies using complexity theory and the types of

methodological approaches employed therein, and from methodological discussions in postmodern and poststructural work¹⁶. The complexity thinking stance adopted in this work builds on ideas developed in feminist and poststructural scholarship that raise questions about the concept of 'research methods' (Gough, 2012, Griffiths, 2009, Lather, 2007) and argue that research should trouble assumptions and normativities and open up new possibilities and questions rather than seek 'answers'.

Although complexity theory has not been so rapidly adopted in educational research compared with other social science disciplines (Kuhn, 2008), interest is on the rise, as demonstrated by the inclusion of a section on complexity in the latest edition of the influential and popular book on research methods by Cohen, Manion and Morrison (Cohen et al., 2007). In this and the accompanying additional information on the book's website (Cohen et al., 2006), they outline three 'standard' paradigms in educational research - the normative (or positivist), interpretive, and critical - before going on to discuss complexity theory as 'an emerging fourth paradigm in educational research' (Cohen et al., 2007 p. 33). They suggest that complexity theory constitutes an emerging paradigm because it 'not only provides a powerful challenge to conventional approaches to educational research, but also suggests both a substantive agenda and a set of methodologies' (Cohen et al., 2007 p. 34). This claim rests on the understanding that complexity challenges simple, linear methodologies and views of causality, suggests that phenomena must be viewed holistically and cannot be broken down (thus moving away from the conventional notion of units of analysis), and requires a focus on interactions. Whilst arguing against positivist, experimental approaches to classroom research, complexity theory does not necessarily imply that only qualitative approaches are relevant: quantitative methods may also be appropriate, linked to non-linear techniques that adopt a multilateral and multi-directional view of causality (Cohen et al., 2006) and understandings based on non-linear and fractal geometries (Davis and Sumara, 2005).

¹⁶ I have chosen not to engage in depth with the literature that discusses complexity theory in terms of the modelling of complex systems, in part due to my lack of mathematical expertise to do so with confidence, and in part because of the particular 'complexity thinking' epistemological approach taken in this work. This is not to say that a more detailed understanding of the work of schools from this perspective would not be valuable and interesting: just that this is one of the way I have reduced the complexity – placed constraints on the work – to enable me to move forward.

Whilst it is reassuring that complexity theory has been viewed as a potential 'fourth paradigm' for educational research, the notion of a paradigm (with its associated Kuhnian concept of rules for 'normal' procedure for working within that paradigm) does not perhaps sit easily with the uncertainty and indeterminism of complexity theory. In this, complexity theory has some commonalities with other kinds of poststructural research such as feminist theory, carried out in what Lather terms the 'post-paradigmatic diaspora' (Lather, 1991). Lather's argument is that work in this poststructural or post-paradigmatic sense is about opening out new spaces for thinking differently, working in ways that are 'not so much linear, as multiple, simultaneous and interruptive' (Lather, 2007 p. 2) and finding ways of 'working the ruins' of methodological certainty (St. Pierre and Pillow, 2000). In this sense, Lather advocates 'getting lost' as a 'philosophy of inquiry', in the sense that 'post' research is about exploration of uncertainty, difference and questioning rather than the seeking of sureties and single right answers. The notion of 'getting lost' is an interesting one in relation to complexity, because if we accept the indeterminism of strong emergence and the uncertainty that arises, it is impossible for methodology to provide a route-map, as we cannot know where we are going. In a sense, we are already 'lost' but rather than seeking a methodological way out, research design and methodology becomes about exploring new territory to create new possibilities. It appears that these two perspectives, that of complexity theory as an emerging methodological paradigm versus complexity theory within a 'post-paradigmatic diaspora' are conflicting, and to a certain extent they are. However, moving beyond the notion of a 'paradigm', perhaps we can see complexity thinking as both enabling and constraining particular ways of exploring the territory in which we are lost, bringing the two approaches together in such a way as to enable us to move forward. As St Pierre and Willow (2000) put it,

Instead of realising Rosenau's (1992) fear that the social sciences might become "casualties of its [postmodernism's] excesses" (p. 3), [the poststructural feminists'] work moves toward a reconfigured social science, a "less comfortable social science" (Lather, chapter 14 in this volume), one that tries to be "accountable to complexity". (St. Pierre and Pillow, 2000 p. 4)

To some extent, this thesis is situated in uncertain ground in relation to empirical use of complexity theory in social science. In preceding chapters I have highlighted some of the relationships between 'complexity thinking' and postmodern/poststructural ideas. On the

other hand, David Byrne has referred to some work in social theory as ‘a declaration of war on poststructuralism and the artillery of that war is the conceptual apparatus of complexity theory’ (Byrne, 2007 p. 337). Given this contested ground, it is clear that in undertaking this research, I needed to find a way of exploring and creating a ‘complexity thinking’ methodology in a reflexive, thoughtful and responsive manner. As Ball puts it,

Method only makes sense if it has some ontological grounding in the theoretical ideas with which the researcher is working and ‘data’ only makes sense in terms of the interpretive resources the research brings to bear...We need to be adept, agile and responsive rather than procedural (Ball, 2011 p. xvii)

In the following, I consider how the ‘complexity thinking’ stance outlined in the introductory chapters to this thesis had particular implications for the way the research was conducted, rooted in important notions of complexity reduction, relationality and temporality. To some extent, this follows the notion of complexity theory providing guidance for research methodology that follow from its ontology and epistemology. At the same time as being ‘accountable to complexity [theory]’, I also explore the ways in which the research takes up the poststructuralist thought outlined above in a methodological sense, and thread both of these elements together in an attempt to create a ‘rigorous’ if uncertain approach to the research that avoids problems arising from the philosophical fallacies outlined by Scott (see p. 103-104). As Byrne puts it, ‘complexity must become more than a metaphorical apparatus in social science and this can only happen if the complexity frame of reference shapes the actual tools of investigative social science themselves.’ (Byrne, 2005 p. 96).

4.2.1 Complexity reduction and methodology

One of the key issues that must be addressed in relation to a complexity-informed approach to research is the question of complexity reduction. In their discussion of complexity-based research methods, Cohen et. al (2007) state that

complexity theory suggests that phenomena must be looked at holistically; to atomise phenomena into a restricted number of variables and then to focus on only certain factors is to miss the necessary dynamic interaction of several parts (Cohen et al., 2006)

This echoes Cilliers (1998) suggestion that any attempt to break down or reduce a complex system in order to understand it cannot work because it would fail to take account of the importance of the interaction between parts in contributing to the emergent complex

system. At the same time, the notion of self-similarity in complexity suggests that breaking a complex system down does not make it any simpler. For example, an individual human is still complex and unpredictable, as is a classroom or a school or a community. At each level of organisation, we might see patterns that appear to be stable, and we might see unpredictable changes. This leads to the suggestion that any complex phenomena must be studied at the levels of their emergence (Davis and Sumara, 2005). At the same time, given the co-existence and interaction between complex systems that, though they may self-organise and cohere into a distinguishable system, are always open to interaction with the surrounding environment and other systems, drawing boundaries around the research focus and selecting what to pay attention to is also problematic. It could therefore be argued that any attempt to undertake research in complexity theory must ignore some fundamental principles of complexity in order to move forward. In a recent article, Gough (2012) problematised complexity reduction through 'methodological borrowings' from other disciplines, including that of evidence-based practice to which I referred earlier in this chapter. He ends his discussion with a question, 'how might understanding our worlds and selves as open, recursive, organic, nonlinear and emergent make 'a different practice' possible for educational inquiry?' (Gough, 2012 p. 53). To further explore this problem, I turn to the concept of complexity reduction outlined in chapter 2.

In my earlier discussion of complexity reduction, I explored some ideas about ways in which complexity might be reduced and the implications this might have for the potential for emergence. An educational example of this might be reduction in complexity by seating students in rows, insisting they work in silence on particular, structured tasks such as copying from the board and so on, in contrast with a class where students work in diverse groups on open-ended questions with teacher facilitation of their exploration by discussing ideas. Crucially though, in both of these scenarios there is still the potential for creative agentic action, uncertainty and emergence, even if it is less likely in the first than the second. This relates to the idea that complexity reduction *is also* a form of complexity production (Rasmussen, 2010), as any action that reduces complexity in social systems means weaving interactions together in *different* ways that have the potential to result in emergent phenomena. In chapter 2, I argued that analysing education through a complexity lens meant paying attention to ways in which complexity is both reduced and produced in a

system, and that if complexity is reduced so far that there is no potential for emergence then complexity theory is no longer an appropriate framework for the research (section 2.3.3). In terms of methodological decision-making, this argument suggests that whilst it is necessary to reduce complexity in order to conduct research, the decisions taken in doing so also produce complexity in different ways. The researcher is part of the research in this framing of complexity and cannot be an external observer; the role of the researcher is both to interact with a real, complex world and also to make that world through their interactions. At the same time, the argument suggests that it is important not to attempt to reduce the complexity of the research too far, as this would render it impossible to analyse within a complexity frame and therefore invalid and subject to Scott's 'pragmatic fallacy'. The result of these arguments is a research approach which attempts to cohere the research around a particular topic without closing down the 'goals' of the research; focussed on particular 'levels of emergence' that are of interest and explored through particular techniques deemed appropriate for those interests and levels; in which the researcher is a part; and in which the research remains open to unanticipated paths which may emerge in the course of the research¹⁷. This is crucial because, as Smith and Jenks suggest, 'strategies of simplification are likely to produce a pandemonium of unintended, unforeseen...consequences' (Smith and Jenks, 2006 p. 4).

4.2.2 'Relational' considerations

Any methods for data collection and analysis informed by complexity theory need to be able to focus on the interactions and relationships within and between complex systems. At the same time, the unique nature of any complex system (in terms of its embodied history and relationships with other systems) means that any knowledge about that system must be contextual (Byrne, 2005). From this, it has been argued (Byrne, 2005, Cohen et al., 2007, Haggis, 2008) that a form of case study methodology is an appropriate choice for complexity-based educational research, emphasising as it does the local and contextual nature of complexity knowledge (Cilliers, 1998). The way in which case study can be taken up as a methodological approach, however, requires careful thought as complexity

¹⁷ Such unanticipated paths that might be followed have been discussed in some complexity and education literature as 'lines of flight', or 'rhizomes', following the work of Deleuze and Guattari. This work has not been directly taken up in this thesis as it needed to be brought to some form of closure, but will be of interest to explore in future work in relation to complexity-informed methodology.

continues to offer the potential to re-think common research methods and strategies as a result of its particular ontological and epistemological base. Firstly, there is the question of how to define the 'case' which is the focus of the research, and secondly, there is the question of what kinds of information about the case are important from a complexity perspective. These questions influence the research design and data collection methods, and the kinds of data analysis that might be considered. In this research, I adopt a case study approach, which is discussed in more detail in section 4.3.

Chadderton and Torrance (2011) consider case study to be an 'approach to research' rather than a methodology that can be 'easily summarised as a single, coherent form of educational research'. They highlight a number of varying ways in which case study has been used in social science, stating that,

What is common to all approaches is the emphasis on study-in-depth; but what is not agreed is where to draw the boundaries of the case, and the extent to which the researcher can produce a definitive account of 'the case', from the outside, so to speak, rather than a series of possible readings of 'the case' from the inside (Chadderton and Torrance, 2011 p. 53)

This suggests that within a case study approach, particular ways of identifying boundaries and locating the researcher in the case, and therefore the particular type of 'case study' conducted, is flexible and dependent on the theoretical basis of the research. Part of the problem in defining the case being researched stems from the open, unbounded nature of complex systems. Seeing the world from a complexity perspective involves viewing it as a series of multiple, connected, open systems which can vary dramatically due to their unique trajectories of emergent development and unique interactions with other, larger systems. This means that one cannot take the step from examination of a particular case to generalisation from that case by arguing that the same 'deep' causes are at the root of all the cases to which generalisation is attempted (Haggis, 2009, Davis and Sumara, 2006). It also means that however the case is defined, the multiple interactions and connections with systems beyond that defined as the case make it difficult to set limits on the research due to the infinite range of interactions that impinge on the case itself. Equating a particular complex system with a particular case appears to be a reasonable strategy (so long as one is confident that the case can reasonably be seen as a complex system), bearing in mind that a

complex system has a 'dynamic coherence' (Davis and Sumara, 2006 p. 100) even if it doesn't have clearly defined boundaries.

One of the reasons why case study is a feasible methodology for complexity-based educational research lies in the emergent organisation of complex systems, which I discussed in chapter 2 as 'relational emergence'. Here, I considered whether individuals, classrooms and schools can just as legitimately be considered complex systems as 'self-organised' collectives such as friendship groups and communities since, at least to some extent, these systems are externally defined. However, taking a complexity view would mean that such 'externally defined' systems, like other systems that are more obviously self-organising, are 'established and [become] viable' through the interactions with other complex systems from which they emerged, and 'the interactions of other, changing systems have been part of the 'internal' structure of the system which is the unit of analysis from the moment it emerged' (Haggis, 2009 p. 9). This means that the 'external definition' is in itself a result of emergent organisation, and that a particular classroom, for example, is still able to learn, evolve and interact with others over time and can legitimately be considered both a complex system and a case. At the same time, however, defining any complex system as the case which is the focus of research implicates the researcher in setting boundaries on the research because of the interwoven and complex nature of multiple connections and interactions between complex systems. As Byrne puts it, 'What is a system of interest at any point in time is defined by observation and action. Boundaries depend on what we are looking for and at. This is not to say that boundaries are arbitrary, relative or unreal' (Byrne, 2005 p. 105). Whether the boundaries placed follow patterns that exist in the complex systems in the real world or not, the necessity of locating a focus of interest and setting boundaries on what will be included in the research is an act of complexity reduction that locates the research within the research field *and* in the system that is 'researched' which, along with the emerging research, may emerge differently as a result of engaging with that research. This has implications for an ethical approach to conducting complexity-based research that will be discussed later in this chapter.

Chadderton and Torrance's approach to case study is to consider a definition of case study that combines a focus on policy, such as a 'case' of curriculum development, with a specific location, such as a school. This creates a focus on the social construction of the case rather

than on individuals as cases, where the study of individuals is then carried out from the position of asking what 'the case' looks like from that individual's point of view. Using complexity, we can extend this argument to collectives as well as individuals. This is an interesting approach to case study in relation to complexity theory for two reasons. Firstly, it is compatible with a notion of nested levels in the complex system that constitutes the case and is also compatible with the notion of multiple, interacting perspectives. Secondly, the idea of coherence around a policy focus is a useful way of creating boundaries around the research to enable the case study to proceed, as it allows 'the case' to incorporate multiple interacting complex systems and avoids the problem that 'too often in the past the boundaries of the case have been assumed to be co-terminous with the physical location of the school' (Chadderton and Torrance, 2011 p. 54). From a complexity perspective, the school might constitute a complex system at a given moment in time, but the assumption is that each complex system is embedded in and interacting with others, in a dynamic trajectory in time. Whilst a complex system *could* be taken as a 'case', it does not necessarily have to be so. Morrison's discussion of the implications of complexity theory for educational research takes a similar direction, though he is not explicitly discussing a case study methodology. For Morrison, complexity theory

suggests that the conventional units of analysis in educational research (e.g. individuals, institutions, communities and systems) should merge, so that the unit of analysis becomes a web or ecosystem (Capra, 1996, p. 301), focused on, and arising from, a specific topic or centre of interest (a 'strange attractor'). (Morrison, 2008 p. 28)

Cohering the notion of the 'case' around a concept of a developing curriculum, then, facilitates the sketching of boundaries around the 'case study', albeit temporary and shifting ones, that is linked to the area of exploration that is the focus of the research.

Thus far, I have argued that a case study methodology is appropriate for complexity-based research, rooted in ideas about the relational nature of complex systems. Accepting that it is reasonable within this framework to examine complex systems as cases, however, is insufficient, and I now turn to consider ways in which this kind of case study methodology goes beyond the normal expectations of case study. The preceding discussion has drawn in particular on the work of Byrne (1998, 2005) and Haggis (2007, 2008, 2009) in arguing for a case study approach to researching complex systems, as these authors have made this

argument explicit in their writing. However, many of the examples of empirical research in the complexity and education literature draw on case studies, with it being implicitly understood that this approach is reasonable. In terms of how these case studies have been conducted, it is often through interpretive methods or mixed methods which might include quantitative elements such as interaction mapping. Haggis suggests an approach to case study that proceeds by choosing the dynamic system which is the focus of analysis, gathering data to enable articulation of some of the range of dynamic systems of which the focus system is a part, and mapping the conditions and effects. She notes that complexity research is such that causes cannot be easily identified (see section 4.2.3) and so research must focus on the observable effects of multiple interactions within the system of interest (Haggis, 2007 p. 40). In terms of methods of data collection, multiple methods may be appropriate.

Texts advising on case study as a research approach suggest that a range of methods can be used to collect information about the case. Sources of data might include interviews, documents, observations and questionnaires conducted both within and beyond the physical location of the case (Stake, 1995). In educational research, case study tends to focus on a 'disciplined, qualitative mode of inquiry' that draws on both anthropological/sociological traditions and applied research/evaluative traditions (Chadderton and Torrance, 2011), making use of 'naturalistic, holistic, ethnographic, phenomenological and biographic research methods' (Stake, 1995 p. xi). Such a use of a range of interpretive methods is a logical one, but complexity insists that attention must be paid in the data collection and analysis to the ways in which these methods afford insight into the relations and interactions within the case, and also to the temporal influences within the case (see section 4.2.3). However, Hitchcock and Hughes (1995) suggest that case studies are distinguished less by their methodologies than by the subjects of their inquiry and that they are particularly valuable when the researcher has little control over events¹⁸. Authors have categorised case studies in various ways, usually based on the reason for

¹⁸ This latter point is particularly relevant in the methodological choices made in this research. Alongside case study, it has been argued that action research and participatory research are appropriate methodological choices for the study of complex systems. This option was not possible for me in my current role, and there is insufficient space to discuss it in depth. In a case study, my role as a researcher means I have much less control over events than the researcher within an action research frame, but nevertheless, case study can be an appropriate choice of research method in studying complex systems.

undertaking the study than on any difference in method. For example, case study might be used to describe and understand a particular case, or to develop conceptual categories and link to theory, or to illustrate in depth some issues derived from larger-scale analysis. Yin (1984) identifies exploratory, descriptive and explanatory case studies; Merriam (1988) categorises descriptive, interpretive and evaluative case study; Stenhouse (1985) identifies case studies that are ethnographic, action-research, evaluative or educational; and Stake (1994) separates case study into three types, intrinsic, instrumental and collective. In the context of the 'complexity thinking' basis of this research, the approach to case study might be defined as descriptive and exploratory, since the effort is oriented towards exploration of the 'present' from a different perspective in order to enable the creation of something new, rather than to answer a particular pre-defined question.

4.2.3 'Temporal' considerations

In the preceding section, I discussed the ways in which case study methodology can be viewed as an appropriate research approach for the exploration of interacting complex systems focused around a particular topic of research. I touched on ways in which interpretive methods commonly used in case study might be used in such research, highlighting the need for these methods to focus on the relational aspects of complex system interactions. In the following, I move on to discuss how the important notion of temporality in complexity theory might influence the complexity-based case study methodology I am developing in this chapter.

The dynamic nature of complex systems and the concept of emergence mean that it is impossible within this framework to ignore the importance of *change* and *time*. At the same time, the ability of human systems to think about and imagine past, present and future means that time is of necessity always present in some way in any educational research: what is important in this framework is that this is explicitly acknowledged. In chapter 2, I discussed the importance of time in relation to mechanistic change, temporal and relational emergence and complexity reduction. Paying attention to the dynamic nature of complex systems, however, does not mean that it is possible to easily discern cause and effect or be able to use descriptions of the trajectories of systems to predict future behaviour. As Haggis puts it, 'the impossibility of tracking multiple interaction histories means that research needs to shift from a focus on cause to a focus on effects.' (Haggis, 2008). This leads us to a

notion of research that allows description of the emerging 'present' of a system through time, to develop a sense of the system trajectory, as a way of exploring the 'space of the possible'. It would seem sensible, therefore, to include a longitudinal element to the research where possible. In light of the discussion of relational agency, identity and reflexivity in chapter 3, and the importance of the concept of feedback loops within complex systems, it would also seem sensible to pay attention to participants' perceptions of past and future, to 'look beyond the immediate and explore participants' memories and explanations of how [they perceive] things have come to be what they are, as well as descriptions of current problems and aspirations' – an important element any in case study research (Chadderton and Torrance, 2011 p. 56).

4.3.4 Drawing together relational and temporal

In the preceding discussion, I have explained the rationale behind adopting a case study approach to complexity-based educational research. In the following, I draw these ideas together to discuss how data collection and analysis might proceed within such an approach. Richardson and Cilliers (2001) put forward a clear argument for adopting 'methodological pluralism':

...the general acceptance [that complex matters demand a methodological pluralism] is not the result of metaphysical commitments, but merely that of trying to understand complex issues with limited (finite) means. If we allow different methods, we should allow them without granting higher status to some of them. Thus, we need both mathematical equations and narrative descriptions... (Richardson and Cilliers, 2001 p. 12).

Using a range of different methods to access some of the variety of information within a complex system, including information about interactions, relationships, perceptions and changes over time, has been proposed in social science literature that is not explicitly 'complexivist'. As already mentioned, the use of multiple methods is common with a case study approach. Often, these methods are qualitative and there is always an element of interpretation in them, but as the quote from Richardson and Cilliers highlights, quantitative methods may be an equally helpful part of the repertoire of techniques that can be used in exploration of a complex system. In creating an approach to the research for this thesis that I felt worked from a complexity perspective, I drew on the ideas of two authors who take a complex, if not a complexity theoretical, approach to social research: Joe Kincheloe

(Kincheloe and Berry, 2004, Kincheloe, 2001a, Kincheloe, 2005, Kincheloe, 2001b) and John Law (Law, 2004, Law and Hassard, 1999).

Law argues that in a messy social world, a world in constant flux, imaginative solutions to the question of method in research are needed. While acknowledging that conventional methodological solutions in social science have an important role to play, the choice of method and its use can only provide a snap-shot of the world-in-flux (perhaps an area that is currently relatively stable) and creates a particular understanding of reality (or a particular reality itself). He notes that while, in the social sciences, there is a wide range of methodological choices to be made, the accounts of method in published research tend to be normative and hegemonic.

...I argue that the kaleidoscope of impressions and textures [I mention above] reflects and refracts a world that in important ways cannot be fully understood as a specific set of determinate processes. This is the crucial point: what is important in the world including its structures is not simply technically complex. That is, events and processes are not simply complex in the sense that they are technically difficult to grasp (though this is certainly often the case). Rather, they are also complex because they necessarily exceed our capacity to know them. (Law, 2004p. 6, my emphasis)

Although Law's work is not based on complexity theory, it is easy to see how the insights above are related to a complexity perspective. In responding to the question of how social science methods might respond to this complexity, Law puts forward the notion of a 'method assemblage' that detects and amplifies patterns of relations in reality, and that is 'more generous and more inclusive' in approach than the usual pre-defined and normative approaches to research, and is therefore better able to deal with uncertainty. This notion of the method assemblage is similar, I believe, to the bricolage approach discussed by Kincheloe and Berry in their attempt to create a rigorous methodological approach that is able to respond to the complexity of real-world social systems. The bricolage concept in educational research can be traced back through Denzin and Lincoln (2000) to philosopher Levi-Strauss, who, in his 1966 work, 'The Savage Mind', used the concept of the *bricoleur*, or handyman/handywoman who makes use of the tools available to complete their task. Kincheloe's rebuttal of those who critique the rigour of the bricolage as a methodological approach will be discussed in section 4.2.5; to begin with I explore his conceptualisation of the bricolage in relation to research methods. Kincheloe's bricolage approach is characterised by an openness to possibilities; the need to re-read and reflect on data from a

range of viewpoints, and the introduction of different methods or tools as one moves further into the complex web of study (Kincheloe & Berry 2004). Lincoln's response to Kincheloe's initial conceptualisation of the bricolage highlights how he moves away from the notion of researcher as a simple handyman, 'Kincheloe's bricoleur is far more skilled, look[ing] for not yet imagined tools, fashioning them with not yet imagined connections.' (Lincoln, 2001 p. 693). Expanding further on his concept of the bricolage, and relating it more closely to a complex epistemology, Kincheloe goes on to describe the notion of the bricolage as an 'active' form of research (Kincheloe, 2005), contrasting it with the passive adoption of normative research methods in a way that resonates with Ball's call for adept, agile and responsive research (see pg. 107). In a sense, the active creation of research through a 'bricolage' of the multi-methodological and multi-theoretical places researchers in the position of 'methodological negotiators' or even 'methodological improvisers' in a way that is in keeping with the logic of strong emergence discussed in chapter 2 of this thesis. The active, temporal-relational agency of the researcher in the research process rejects deterministic views of social reality, and requires that researchers bring their understanding of the research context (in this research, the 'case') together with their understanding of research methods to create new understanding of both context and methods. Kincheloe suggests that this,

is a high-level cognitive process involving construction and reconstruction, contextual diagnosis, negotiation, and readjustment. Researchers' interaction with the objects of their inquiries, bricoleurs understand, are always complicated, mercurial, unpredictable and of course, complex. Such conditions negate the practice of planning research strategies in advance. (Kincheloe, 2005 p. 325)

The difficulty of planning research strategies in advance in a complex framework is one aspect of the dynamic of emergence in complex systems that makes conducting research in this framework particularly challenging. The notion of the 'method assemblage' or the 'bricolage', in which the researcher builds a pattern of methods to research the complexity of the social world, including interactions and relationships through time, ties in with the range of strategies commonly employed in case study research. The difficulty is that within a complexity stance, there is no way of knowing which methods will be most helpful to explore the emerging case, as there is no way of knowing how the case will emerge and what will become of interest in the related emerging research. For the same reason that

particular research questions could not be identified in the earlier chapters of this thesis, I was also unable to identify in advance the methods of data collection and analysis that would be used. Instead, the relational and temporal case study methodology employed in the research utilised the concept of the bricolage in tandem with the notion of emergence to remain open to the possibilities that might emerge through the research as it moved forward through time. In section 4.3, I discuss in retrospect the particular methods and analytical techniques used.

4.2.5 Validity, Rigour and Trustworthiness in Complexity-based research

The complexity theoretical framework and the resultant interpretive case study research approach developed in this chapter have implications for the validity, reliability and rigour of the study and its findings. Concepts of validity and reliability as indicators of rigour and quality in research stem from assumptions of an objective reality that can be observed and understood by value-neutral researchers. Validity addresses questions of whether the research can provide an accurate representation of its object of study, and reliability relates to whether the same findings would be found if the research were repeated. From a complexity perspective, neither of these measures of rigour are appropriate: Firstly because of the impossibility of full representation of a complex system since to do so, any representation would have to be as complex as the system itself (Cilliers, 1998) and secondly because the situated nature of the researcher in the system, and the dynamic nature of the system, mean that the system must be changed by the research and so replicability as a measure of research reliability is impossible. We must therefore seek out alternative ways to attempt to ensure that research is rigorous and of good quality that are in keeping with the theoretical stance of the research.

In interpretive studies, judgements about research quality are made through concepts of trustworthiness and a clear sense of the 'warrant for knowledge' within the research (Guba and Lincoln, 1994). Advice about ways of ensuring the validity of methods of research which may be employed within the bricolage or method assemblage will be both useful and important in ensuring the research undertaken is rigorous. Any methods employed should be employed with skill, but also based in an understanding of both what they bring to the developing picture and what their limitations are. Therefore, guidance in the literature (Denzin and Lincoln, 2000) about validity in interviews or questionnaires through the

avoidance of leading questions, for example, must not be ignored, and I refer to these concepts in the discussion of specific methods used in the research in the second half of this chapter. Although the bricolage approach has been subject to critique by those who feel it lacks theoretical clarity and in-depth skill in a given discipline, Kincheloe and Berry (2004) argue that the bricolage approach is in fact *not* an avoidance of the question of rigour and quality. They argue instead that the ability to respond to the emergent data and to open spaces for thought is exactly what would be required for rigour and quality in researching the complex social world. The logic of this approach ties to the logic of emergence outlined earlier in this thesis, but it does not provide a simple solution to ensuring quality in complexity-theoretical research in education or social science, as it pushes the researcher to ongoing engagement with the development and skilled employment of a range of research methods. Indeed, Kincheloe argues that this is a lifelong commitment and not something that can easily be developed within the short length of research training that constitutes a PhD (Kincheloe, 2001b). I have therefore done my best in this research to act as a *bricoleur* in as rigorous and skilled way as possible, and I have outlined how I have attempted to do this (including through the keeping of a reflexive research journal) in section 4.3.

Ensuring that the fallacies which may compromise the rigour of a piece of social research identified by Scott are addressed is a good starting point, providing a minimum expectation on which careful implementation of research methods can build. I listed these fallacies at the start of this chapter, and the complexity thinking methodology developed addresses them in alternative ways to those offered by Scott's critical realist approach. The epistemic fallacy is addressed through the way in which complexity theory offers a clear ontology of a real, complex world, and an epistemology around ways we can come to know complex systems and undertake complexity research (see Cilliers, 1998). The fallacy of homogeneity is addressed within complexity as rather than assume that the characteristics of a group can be applied to individuals in that group, complexity examines relationships between individuals and groups through the understanding that nested levels of complex organisation interact to produce emergent effects. The causal fallacy, in which observed effects are construed as causal configurations, is related to the prospective fallacy in which retrospective viewpoints are conflated with prospective views. These are both addressed by the complex understanding of non-linear causality and the logic of emergence. From a

complexity perspective, it is impossible to pick out the relationship between particular causes and their effects, and it is impossible to determine the future emergent direction of a system, not because of inadequacies in the research approach but because of the nature of the 'case' as understood from a complexity perspective. As discussed earlier in the thesis, this does not mean that complexity research is not useful, but orients the research differently and in such a way that these fallacies are not likely within a complex framework. The essentialist fallacy speaks to the problem highlighted in complexity theory of the impossibility of accurate representation of complex systems, as any representation will always miss some aspect of the complex system, although such work can be undeniably useful. This makes it impossible from a complexity frame to mistake the appearance of the system as the whole of the system. The fallacy of value-free knowledge would ignore the location of the researcher as an interacting part of the system that is being researched and the emergent knowledge that is created as a result – complexity-based social research demands the location (and therefore the values and embodied history) of the researcher within the research. Finally, the reductive and deterministic fallacies are addressed through the very nature of complexity thinking, which is oriented towards emergence, exploration and creativity. This suggests that complexity thinking offers a potentially rigorous ontological and epistemological ground from which to conduct pragmatic empirical research, even though the nature of rigour in such empirical work stems not from following tried-and-tested methodological rules but from responsive and exploratory approaches to local and contextual research. This quote from Kincheloe encapsulates the concept of rigour in the complexity-informed bricolage approach to research:

In this thick, complex, and rigorous context, bricoleurs in the social, cultural, psychological, and educational domains operate with a sophisticated understanding of the nature of knowledge...In this ontological framework, they concentrate on social activity systems and larger cultural processes and the ways individuals engage or are engaged by them...Bricoleurs follow such engagements, analyzing how the ever-changing dynamics of the systems and processes alter the lived realities of participants; concurrently, they monitor the ways participants operate to change the systems and the processes. The complexity of such a mode of inquiry precludes the development of a step-by-step set of research procedures. Bricoleurs know that this inability to proceduralise undermines efforts to "test" the validity of their research. The researcher's fidelity to procedure cannot simply be checked off and certified. In the complex bricolage the products of research are "evaluated." The evaluation process draws on the same forms of inquiry and analysis initially delineated by the

bricolage itself (Madison, 1988). In this context, the rigour of research intensifies at the same time the boundaries of knowledge production are stretched. (Kincheloe, 2001b p. 689)

4.2.6 Responsible, responsive and ethical complexity-based research

In previous chapters I have briefly mentioned some questions that have been raised in the literature over how concepts of responsibility and ethics can be articulated in a complexity framework. These concerns appear to be drawn from three general points. The first of these is that complexity theory is essentially descriptive and amoral, with moral debate and choices seen as irrelevant. The origin of complexity theory within the natural sciences is cited in this argument, where it is suggested that this origin means complexity theory 'does not inherently offer constructs that speak to educational responsibility' (Fenwick, 2009b). If complexity theory is directly translated from natural sciences, then the presumed 'value-free' tenet of science might logically be adopted in complexity theory analyses in the social sciences. Similarly, the idea that complex systems evolve and adapt in order to survive translates into the notion that complexity theory follows the 'amoral law of the jungle' (Morrison, 2008 p. 29) and the survival of the fittest. If true, this would be problematic for any social research, but it is seen as particularly problematic in relation to education, as education is itself a moral enterprise (Morrison, 2008). The second area of difficulty in thinking about ethical action within a complexity framework comes from the indeterminacy and uncertainty inherent in the theory. Since it is impossible to predict the future, complexity theory is only able to describe parts of the past or present and it is logically inconsistent with the theory to 'move from an 'is' to an 'ought'' (Morrison, 2008 p. 29). This leads us to a challenge: If the future is radically uncertain and unpredictable, the question of how it is possible to act responsibly towards that future is a difficult one to answer. If the consequences of any action are unpredictable, and the same behaviour may not lead to the same result, it becomes difficult to understand how to take responsibility for ethical action. The third point where it is argued that complexity theory fails to speak to ethical responsibility lies in the concept of distributed control and networked interaction. If concepts like agency and power are relational, and an individual's actions are constituted within a wider complex web of interactions, is individual responsibility for ethical behaviour possible, and if not, how can collective ethical responsibility be conceptualised? These three challenges to thinking about the concept of educational responsibility and ethical action

mean that it is necessary to think carefully about what constitutes responsibility and ethics when taking part in educational research. Fenwick (2009b) believes that a complexity framework is helpful in problematising core assumptions of responsibility and reconfiguring what responsibility, and therefore ethical action, means in a complexity frame. Ultimately, complexity theory cannot tell us how to act ethically, as it is impossible within this framework to prescribe correct action. However, a complexity approach to relational agency, subjectivity and power can offer alternative ways to think about and explore ethics within an emerging educational case study such as the one undertaken in this research.

The notion that complex systems are value-free because they simply learn, adapt and survive stems, I believe, from problems associated with straightforward translation of concepts from the natural sciences into the social sciences and ignoring the particularities of emergent aspects of humanity such as consciousness, conscience and imagination. As a result of these emergent aspects of human existence, it can be argued that complex social systems are capable of engaging with ethical issues in ways that non-human systems are not. Indeed, in any given research context, the researcher, as a human interacting with the system, is always already engaged in taking some form of ethical decisions in relation to the research, as even within the 'hard' experimental sciences, it is recognised that the social construction of scientific knowledge involves ethical choice (Barnes, 1996). Since humans, both individually and collectively, are embodied within complex social systems, it would be remiss to ignore the ethical dimension to research and action within those systems by attributing this to an amoral nature assumed to be present within complexity itself. The nature of complex systems, as described in the early chapters of this thesis, leads to the insight that the researcher is embodied within the system that is being researched and this leads to an ethical stance of participatory and reflexive research, as argued by Horn,

...the need to observe complex human systems as comprised of fully embodied interactive agents...highlights the importance of viewing the researching of such systems from an ethical perspective. It will be the interactive and reflexive research practice based upon this recognition that instantiates the ethical ideal, which would yield a research practice in which humans are not subjected to research but, rather, are acknowledged as participants engaged in the ongoing elaboration of the communicative behaviours that include researchers as well. (Horn, 2008 p. 141)

As a result of the complexity thinking approach developed in this thesis, I take the view that the ethical is a fundamental part of the emergence of complex social systems, and that the

researcher is part of the system and implicated in the unfolding of the emergence of that system in relation to the research. Regardless of the origin of complexity thinking, I do not believe it to be inherently unable to 'speak to' questions of ethics. However, what it means to act ethically in educational research from a complexity thinking frame requires further elucidation.

The insight that complexity thinking means that knowledge is local and contextual, and that the logic of emergence means that the future is unpredictable, means that ethical complexity-based research needs to be rooted in and responsive to the context of the research. In section 4.3.4, I explain the particular ethical stance adopted in this research, with examples of how I worked in an ethical manner. This stance was drawn out of a 'complexity thinking' re-thinking of ethics using concepts of complexity reduction and emergence in a similar way to my engagement with notions of power, agency and subjectivity in chapter 3. Ethics can be seen as a form of complexity reduction, if it is closing down particular 'options for action', or minimising recursion within the complex system even for apparently excellent or just reasons. Biesta (Biesta, 2010a) discusses the politics of complexity reduction, asking who is reducing complexity, and for what reason; this is a political and also an ethical question. Making ethical choices acts prospectively because it is oriented towards the imagined future that may result from the action, making it a form of prospective complexity reduction that is analogous to the assessment example Biesta gives (see section 2.3.3). During periods of mechanistic change where the system is close to equilibrium and some form of emergent organisational stability is found, such prospective ethical judgement and action may continue to be feasible. However, in any complex social system, there is always the potential for emergent change in which what it means to act in an ethical way might not translate into the emergent future contexts. Earlier, I argued that any act of complexity reduction must also be an act of complexity production, as a result of the logic of strong emergence and the temporal nature of complexity. This argument holds in relation to ethics, which can be seen as a form of complexity-in-action, with ethical action emerging in and through the complex system. Such ethical action cannot be 'ethical' in the sense of attempting to act to produce a particular form of 'good' or 'right' *future*, so ethics in a complexity framework needs to be understood differently from the emancipatory ethics of critical or feminist theory, for example. Instead, ethics in relation to the temporal

conceptualisation of emergence becomes ethical action in the present moment where choices are made to avoid causing harm combined with an ethical responsibility to the future which involves exploration of the present and experimentation with the 'not yet possible' (Osberg, 2010a). Osberg's argument in relation to politics and education is that,

Emergence can be understood as a kind of normative force in that it guides in a way that is non-arbitrary, based on the rules of the past, which is nevertheless non-normative because it exceeds the rules of the past. It does this by using the rules of the past in an experimental way to create something radically new, something which is beyond the rules... (Osberg, 2010a p. 163)

Thinking about ethics in educational research using this argument suggests that the rules, guidance and standards of ethics formulated in education in documents such as the BERA guidelines (BERA, 2004) can be used within the research, and used ethically, in an experimental way that is responsive to the emergent conditions of the case. As Osberg suggests, this experimentation with the possibility of the impossible '*already inhabits other understandings of care and responsibility [such as those found in feminist theory or emancipatory educational research] and fulfils their ethical requirements*' (Osberg, 2010a p. 163, her emphasis). This shows how it is possible to act ethically within a complexity thinking framework in terms of orientation to the future.

The final problem I identified in the literature in relation to complexity and ethics was the question of how to understand ethics when control is distributed throughout the complex system. If the researcher is understood as part of the system, then their actions influence the emergent trajectory of the system at least in some way, no matter how hard they try to minimise such influence. Ethically, this must be recognised and the concepts of ethics in interpretive research are relevant and helpful here, advising as they do that the researcher maintains a reflexive awareness of their role and actions in relation to other research participants. Using parallel arguments to those in chapter 2, we can draw out a relational approach to ethics, like relational agency and power, where ethical action is understood as emerging in interactions with others and not something that is imposed or is solely the responsibility of the researcher. This does not negate the fact that the researcher *has* ethical responsibility, but that it is enacted in relation to others and exists in a responsive way rather than as something that is imposed.

My arguments in this section lead to a conceptualisation of ethics in complexity-based research that is relational and responsive. I see myself as the researcher as situated within the complex systems that relate to the research 'case' of curriculum change, and ethics as something that is enacted in response to and in interaction with the participants in the systems. I also see ethics as enacted in continuous response to the emerging present, necessitating ongoing ethical thought, and experimentation with or adaptation of the ethical guidelines with which I work if this becomes necessary as the research emerges. Researcher reflexivity to record the responsive decision-making and enactment of ethics is therefore a crucial aspect of research within this framework. In the second half of this chapter, I explain how the complexity thinking methodological stance outlined thus far was enacted in the empirical work of this thesis.

4.3 A Case Study of Curriculum Change

In this section of chapter 4, I explain how I adopted the case study methodology outlined in section 4.2 to explore the changing curriculum that formed the topic of the case study. In line with the ideas outlined above, I attempted to engage with the case from multiple perspectives whilst maintaining a sense of my own involvement in the complex system and a responsive approach to the ongoing trajectory of curriculum change. At the same time, I recognised that I would be unable to faithfully represent the full complexity of the case and that in my research, I would be creating an emergent understanding of the case in relation to a theoretical framework in an attempt to create new knowledge. This means that concepts such as saturation and triangulation were not feasible within this framework. Instead, I took the view that in engaging with the case and seeing the research as a creative act, I would need to be clear in the reasoning behind the decisions I took, but that these would need to be in response to what I was able to do in the context and the time-frame available to me.

4.3.1 Data Collection

Within the case study methodology I used in this research, I used predominantly qualitative data and interpretive methods to seek information about participants' experiences of the new curriculum. I also made use of quantitative approaches, but exploited them as a way of gaining alternative insights into the case, using them in an interpretive sense, and recognising that the use of quantitative techniques and statistical methods was non-

inferential and that the results obtained in these only contributed to the local picture of the case and not to any form of generalisability. Numerous texts on qualitative and interpretive research address their particular strengths, including their capacity to generate rich and thick descriptions and respond flexibly to participants' experiences and descriptions, remaining open to emerging circumstances or new questions that might arise (see Cohen et al., 2007, Denzin and Lincoln, 2000, Silverman, 2000).

Over a period of 18 months, 15 teachers and 14 students were interviewed, 19 lessons observed, and questionnaires conducted with the whole school staff and students in the three year groups (ages 11-14). Curriculum documentation was also qualitatively examined, as were examples of students' work from observed lessons. Table 5 shows a timeline of data collection in relation to the policy context and the trajectory of the changing curriculum. Observations and interviews were conducted on both formal and informal bases as opportunities arose during the period of the research. In this respect, the research 'design' used a sampling approach that could be described as both opportunistic and purposive because whilst I sought out particular teachers and students to talk to and observe because of the research focus on the changing curriculum, I also followed up on opportunities that arose as the research continued, talking to people who were interested in talking to me. In fact, the research was also both opportunistic and purposive in the choice of case study: It was opportunistic because I conducted the research in a setting to which I was able to gain access due to both my relationship with the school as a teacher educator and informally through my partner, who is a teacher there (albeit in a department which was not the focus of my research). This meant that although the choice of this school for the case study was mediated by the relative ease of access, it was also purposive in that this was one of the schools in the area that was making changes to the curriculum in relation to 'learning to learn' that was of particular interest to me. A combination of opportunistic and purposive sampling can be justified in research of this type if the potential for learning is the most important criterion for choosing case, whilst recognising that this potential is dependent on practicalities such as the need to obtain access (Stake, 2003 p. 153). Further justification can be found in the responsiveness to emergence necessitated by the complexity basis of this research.

Once data collection began, I took the decision to focus my data collection predominantly on the teachers, as I became increasingly interested in the way they responded to the combination of freedom and control in their work with the new curriculum. However, keeping in mind the need to gain multiple perspectives (based on the complexity theoretical frame as argued above), I continued to include students in my data collection. I also became interested in the different ways the teachers who were involved in the new curriculum and those who were not responded to the changes, and chose to focus my interest in the case in relation to this aspect on the science department for reasons outlined in the introductory chapter of the thesis.

Table 5: Timescale of data collection in context.

	1/9/07 – 31/8/08	1/9/08 – 31/8/09	1/9/09 - 31/8/10	1/9/10 – 31/8/11
Policy Context	Announcement of change to national curriculum (QCA 2007)	Announcement of end of National Curriculum Tests at age 14.	May 2010 – general election leads to change of government with significant policy change in education	
Broad stages in OM curriculum development	School working party begins to develop Year 7 curriculum in response to change. New 'OM' Curriculum drafted by teachers.	1 st OM cohort taught OM curriculum continued to be planned and developed during the year, as 1 st cohort taught.	2 nd OM cohort taught OM curriculum updated in response to 1 st year through and 'Opening Mouths' critique from other staff. 'Triad' CPD model includes OM element.	3 rd OM cohort taught Further development of OM curriculum, in response to RSA branding of 'Opening Minds Schools' Further attempts to spread 'OM' through the school into subject lessons and older year groups.
Data collection		Interviews with teachers begin in summer term. Interviews with: Winnie and Jim Lesson observations in summer term: 7D8 (Declan); 7S8 (Sarah)	Interviews with teachers undertaken throughout the year: Winnie, Daniel, Declan, James, Kate, Isaac, William, Ralph, Toby, Jacob, Louise, Matt. Student interviews undertaken in Spring term: ten individual interviews across tutor groups in current year 7; two group interviews with current year 8. Lesson Observations undertaken in Autumn and Spring terms: Opening Minds: 7D9 (Daniel) x 3; 7J9 (James/Declan) x 2; 7W9 (William) x 3; 7S9 (Sarah) x 2; 7K9 (Kate) x 1; 7F9 (Felicity) x 2; 7I9 (Isaac) x 3. Other: 3 x Science lessons Questionnaires conducted with staff and students in Years 7, 8 and 9 in the Autumn term.	Final teacher interviews completed in Autumn term with Daniel.

In combination with the opportunistic and purposive sampling already discussed, the research also used theoretical sampling, where methods were employed in different ways in response to developing ideas drawn out from the relationship between data collection, ongoing data analysis and the theoretical framing of the research. The notion of theoretical sampling, developed in grounded theory, enables the researcher to test the theory that is being developed from the data, and is relevant here (Charmaz, 2006). Although the approach taken was not one of grounded theory, the responsive and recursive nature of this approach is in keeping with my complexity theoretical stance. The main methods of data collection employed within the complex 'bricolage' in this research were interviews, lesson observations and questionnaires. Each method allowed different insights into the case to be gained, allowing a responsive approach to developing ideas.

Interviews

During the research, I conducted formal interviews with Opening Minds (OM) teachers, science teachers and members of the senior leadership team in the school (see chapter 1 and 5 for discussion of the Opening Minds context and curriculum that is the focus of this case). I also interviewed at least one, and usually two members of each Year 7 tutor group during 2009-10. These interviews were one-to-one. In addition, I interviewed four Year 8 students, in two pairs. My approach to interviewing was semi-structured (Kvale, 1996). For each type of interview, I created a loose schedule that included some questions to prompt the interview towards the topics of the research. However, I also kept the interviews open and flexible, seeing them as a form of 'conversation with a purpose' (Burgess, 1984 p. 102) in which I needed to be responsive to the participants' ideas which might take the research conversation in emergent and unexpected directions. At times, I kept quite closely to my interview structure and at times, I abandoned it, choosing instead to follow the unfolding conversation. I used prompt questions to follow up on interesting responses and encourage further insight, including 'can you tell me more about that?' and 'can you give me an example to show me what you mean?'. I also reflected my interpretation of their comments back to the participants to check that they were happy with how I had understood them. With the Opening Minds teacher interviews, which generally followed on from a lesson observation, discussion of the lesson regularly became a focus despite not being included on the interview schedule. The interviews were digitally recorded with the permission of the

participants, and during the interviews, I made notes if appropriate as reminders to come back to certain topics and as an aid to transcription, as many interviews took place where there was background noise from nearby classrooms or corridors. Appendix 1 includes examples of the interview schedules.

Lesson Observations

At the beginning of the research, I designed lesson observation schedules to focus the observation on how the teachers used the structures and language associated with Opening Minds in the lessons, and how/who the teachers interacted with in the lesson. I quickly found that these schedules were problematic to use, as I needed to be responsive to what was occurring in the lesson. I found that I regularly abandoned them during observations as the lessons went in unanticipated directions, eventually preferring to go in to lesson observations with a blank page and an open mind. Examples of the original observation schedule and an open-ended page of observations are included in appendix 2. Bearing in mind the advice in the case study literature, and the importance of relationship with the material world as well as the social relationships in the class, I attempted to capture some details about the material setting of the lesson as well as the activities, lesson structure and language used. I took a stance as a semi-participant observer, in that on the whole I spent the lessons I observed watching and taking notes, but I was always prepared to participate if asked, either by the students or the teacher. The teachers always introduced me as a researcher from the University finding out about Opening Minds, and I answered students' questions about my work if they asked me. Generally, the students were so used to having observers in the lesson that my presence was not unusual and was accepted easily by the students. On occasion, particularly as they got to know me better (and knowing that I have a teaching qualification), teachers asked me to undertake a role that involved greater participation, leaving groups of students with me. It was in the lesson observation element of the research that I found myself most challenged in moving from a 'teacher' and 'teacher educator' role to a 'researcher' role, and I used research diaries and conversations with more experienced colleagues to support me in this. The diaries enabled me to reflect and develop a clearer sense of when I felt difficulties arising from this overlap, which I then took to supervisory conversations if my experiences raised questions about the conduct of the research.

Questionnaires

Questionnaires including both quantitative and qualitative elements were used to get a broad-brush perspective of the case. An online questionnaire was used to elicit staff opinions about the wider curriculum policy changes and the specific changes begun in the case study school. Pencil and paper questionnaires were conducted with Years 7, 8 and 9 during the year 09-10, when Year 9 had not been part of the Opening Minds initiative, but Years 7 and 8 had. This questionnaire was designed to investigate students' attitudes towards Opening Minds in particular, and towards learning in the school more generally. As well as giving a different perspective on the case for the purposes of my research, the questionnaires were also designed to help the school in their evaluation of the Opening Minds initiative, and following analysis of these questionnaires, a short report was prepared for the school's use. In this report, all identifying features were removed to respect the anonymity and confidentiality of the participants. These questionnaires were developed through a process of piloting, reliability testing, refining in discussion with school staff, and expert checking for validity. The questionnaires, along with a description of the processes used in creating them, can be found in appendix 3.

4.3.3 Analysis

In my research, the bricolage methodological approach was not simply about using a patchwork of methods to access data about the case from a range of perspectives. It also informed the analytical approach I took to interpreting my data. Following Kincheloe and Berry (2004) the data needed to be analysed from a range of perspectives (inasmuch as that is possible, given the research framework and the researcher's personal values and beliefs). I used a range of analytical approaches to exploring my data, which included a combination of open coding and comparison across participants, detailed examination of the data associated with individual participants, and theoretically driven coding which took key ideas from the complexity theory framework and identified places in the data that explore these ideas. In the following section, I begin by giving a general outline of the analytical process I undertook in this study, after which I provide a more detailed discussion of the iterative process of grounded and theoretically-driven coding used in this work.

I saw a key part of my analysis as immersion in my data, and began analysis by listening to the recorded interviews many times. Once transcribed, I read and re-read the data, making notes in the margins of questions and ideas as I did so. Once I began coding, I did so within the nvivo8 software, which enabled me to annotate, highlight, code and attach research journal notes to the data easily. Within this software, I was also able to analyse lesson observation data alongside interview data. I searched for patterns of similarities and difference in the sorts of language teachers and students used to describe their experiences and interactions with the developing curriculum. Re-examination of the developing data throughout the life of the project was also necessary, since the ways in which patterns and ideas emerge from researcher interaction with the data changes over time as the case develops alongside the research. The recursive nature of such an approach to data analysis is part of the complexity-theoretical approach that enables emergence of the research in new directions. To keep track of the developing interpretation within this approach, it was necessary to keep a research journal through the process of analysis, as discussed by Kincheloe and Berry in their conceptualisation of rigour within a bricolage approach (Kincheloe and Berry, 2004).

I began coding by drawing on some strategies that have been clearly articulated in the literature on grounded theory (Charmaz, 2006), although my approach to the research included a strongly developed theoretical stance prior to data collection and so it cannot be said that I employed a grounded theory approach. Gbrich (2007) refers to this as 'quasi' grounded theory, where the strict approach developed by Glaser and Strauss has been modified so that only part of their structured approach is used. I began by attaching descriptive codes to label pieces of data, which could be sentences or paragraphs in interviews, or incidents or quotes in observation data. I also used a tactic of 'in vivo coding' where I felt that the participants' own words articulated a key concept I was interested in very well. An example of this was the description of Opening Minds by one participant as 'more human'. I found Strauss' guidelines supporting constant critiquing of the data useful in this open coding process, in which the researcher constantly asks during coding: 'What is going on here? Why is this being done? What if this or that changed? What does this incident indicate?' (Strauss, 1987, adapted by Gbrich, 2007 p. 74).

During the open coding of data, I moved between comparison of the codes generated by the different participants (or different groups of participants in observation data) and examination of ways in which the codes identified in the data differed between participants or groups of participants. In this way, I sought to move beyond coding as a way of describing the data and towards the identification of relevant themes in the participants' exploration of their work in relation to the changing curriculum. This led to themes that related broadly to participants' beliefs about education, and ideas about what Opening Minds is or should do. At the same time, this process identified codes which linked these two categories together, such as 'reflection', and allowed me to identify places where the teachers' general beliefs were in tension with their ideas about Opening Minds. As the analysis emerged, I found it was important to pay attention to the tensions within the data, which could be missed if categorisation and thematic analysis were the sole analytical technique. This has been discussed in depth by Haggis (2007, 2008), who argued that the standard cross-sectional comparison of individual participants in order to identify themes can be problematic from a complexity perspective. The problems arise if the themes, found in similarities in the data, are assumed to represent a simple underlying cause: Complexity, with its concept of multiple, networked causality, suggests that such an interpretation is impossible. For Haggis, a further problem is that a thematic cross-sectional analysis is only able to pay attention to patterns of similarity in the data, and not to differences or to interactions within and between systems. Instead, she argues for a form of 'dynamic systems abstraction', where each participant is analysed in terms of different system interactions, moving from the individual to the wider collectives within which the individual is constituted, and which are, in part, constituted by the individual. Haggis does not suggest that coding through comparative analysis is not useful in complexity-based studies, just that it is not sufficient, and that attention needs to be paid to 'interpreting meanings in context', where meaning arises *in the interactions between participants, and with the researcher, which result in the data and its' interpretation*. In my research, this meant that alongside open coding and comparative analysis, I maintained an openness to tensions and differences within the data and looked at these from the perspective of interactions within the system. I also used diagrammatic ways of interpreting the data, using sketches of interactions which I labelled with codes drawn out from the interview data as well as notes in written form. This diagrammatic approach to interpretation drew on Clarke's articulation

of situational analysis as an extension of grounded theory that attempts to handle multiplicity, difference and interaction alongside comparison in qualitative analysis (Clarke, 2005). Clarke's approach is a helpful one in relation to complexity-based analyses, and although I did not employ the specific types of mapping she advocates, her ideas and approach helped to develop the analytical bricolage I used in this work.

One of the main representational techniques I used to analyse the data in relation to the concepts identified in chapters 2 and 3 of this thesis was a form of 'matrix analysis' (Richards, 2005), which I used in the latter stages of my analysis to explore tensions within the data. This aspect of data analysis took place following the analysis and interpretation of the data through the preceding processes of open and theoretical coding which are described in depth below, and was used to enable me to link the analysis and interpretation of the data presented in Chapter 6 to a discussion of wider literature and theory. The approach to matrix analysis used in this study is also described in greater detail in the following section.

The combination of open coding, analysis through mapping and sketching the data, and matrix analysis allowed me to explore the data in a range of different ways and bring the insights from each together in my emerging interpretation of the research. Keeping a research journal as a tool to maintain rigour in the interpretive analysis was an important aspect of my methodological approach, as this also allowed me to track how my ideas and interpretations developed in conversation with the data alongside the wider reading around the topics of the research that I engaged with throughout the research and the conversations I had with colleagues and others. Within the complexity framing, my situation within the complex system that was the physical location of the research was important, but it is also necessary to recognise that I was also situated within other complex systems, including the discipline of education, the University, my own friends and family, and so on. These all had effects on my interaction with the case and the research that developed as a result, and the research journal provided an opportunity to track these interactions.

Details of the coding process

The analysis of the interview and observation data in this study provided a significant challenge for me in relation to balancing a 'bottom-up' approach to data analysis with a

‘top-down’, theoretically informed route. Partly this challenge arose because in this study, both approaches to analysing the data are relevant from within the complexity theory framework which formed a guiding theoretical perspective for the study. A bottom-up approach to coding maintains an open stance to emergence, by paying attention to the voices and ideas of the participants as they developed in conversation, open-ended questionnaire response or in a situation that was being observed. In a sense the process of open, bottom-up coding used here is a form of relationship between the data from the participants and the researcher analysing the data, as although this type of coding focuses on the voices of the participants, these voices are interpreted by the researcher. Open coding may therefore be seen within a complexity frame as a type of ‘space of emergence’ in which new ideas, knowledge or understand can ‘come into presence’ through the process of analysis.

Retrospectively, it is possible to describe the coding process I used in this ‘open-coding’ phase in two stages; an initially tight, descriptive phase that stayed very close to the data, and a thematic phase which identified broader themes within the data which were more likely to be informed by my own interests and on-going thinking about the study. However, it would be inaccurate to suggest that these two phases occurred as two separate steps, with line-by-line coding followed by the identification of themes. In reality, the process was more messy and organic, with both tight, descriptive coding and thematic coding occurring concurrently and iteratively as I worked through the data. This can be seen in the codes attached to the piece of data shown in Figure 6¹⁹, which highlight both descriptive codes (e.g. ‘planning’, ‘OM is tiring’) and more thematic codes (‘freedom’ and ‘structure’). (A longer example of the coding process is shown in Appendix 6.)

¹⁹ The examples included here have been translated from nvivo into Word, with codes shown in comment boxes, to facilitate simplicity of representation

K: From the teaching point of view, it's great fun, but incredibly tiring I must admit.

LH: In what way?

K: I think it...Yes, I'm normally RE, I think it's the, the amount of...this was my first year through so obviously I've got 14 lessons over the two weeks to prepare that are all completely new. And apart from when they are actually on task, the planning bit has to be quite structured. So that, it has to be structured to enable them to have freedom, that's how I feel.

LH: That's really interesting; can you explain a bit more what you mean?

K: Well, in order to facilitate their freedom of...creativity, you have to...have facilitated or planned for those – not for every outcome – but so that they are actually free within the creative....But you have to...I'm not explaining myself very well.

Comment [L1]: Enjoys OM
Comment [L2]: OM is tiring
Comment [L3]: Lots to prepare – time commitment
Comment [L4]: Structured planning
Comment [L5]: Structure AND freedom
Comment [L6]: Planned outcomes – but not all
Comment [L7]: creativity

Figure 6: Example of coded data

Having worked through data from individual participants in this way, I found I had created a series of codes at different ‘distances’ from the data, which I began to explore by combining some sets of codes together under a wider label. However, I found that some of these labels were still broadly descriptive of an aspect of the case, whereas others tended to describe a more theoretical interest. Examples of these different elements of the developing coding frame are shown in Table 6 below. Some of the thematic labels used at this stage had already been identified as themes during the initial phases of coding (for example, ‘reflection’, ‘creativity’, and ‘structure’). Again, I continued to explore the data in a relatively organic fashion rather than following strict stages, as ongoing data collection occurred at the same time as I began the analysis, meaning that I continued to work through data from individuals, as well as exploring data across participants using the emerging coding frames.

Descriptive Label	Example sub-codes	Thematic Label	Example sub-codes
Beliefs about Education	Teaching Skills	Structure	Planning
	Teaching Knowledge		Timetable
	Getting students to think		
What is Opening Minds?	OM is different	Reflection	Student reflection
	Breaking down subject barriers		Teacher reflection
	Language of OM		

Table 6: Examples of developing codes and labels

At this stage of coding, I had begun to identify a series of ideas within the data that appeared to be important in this particular case of a changing curriculum, drawn out predominantly from the types of code labels I was thinking of as 'descriptive'. I was concerned at this point in the process that I was struggling to pull out themes from the open coding that I could clearly link to theory: the pyramid from data to themes and theory that research methods courses appear to suggest was not so easy to create as I had anticipated. I turned here to sketches of the system using code labels to help me in attempting to interpret and analyse my data (See appendix 7 for an example). I also began to explore the tensions that were becoming apparent both within and between individual participants' responses, and the responses when viewed as groups of teachers. I found that aspects of the 'descriptive' codes showed up tensions within some of the 'thematic' codes, where, for example, descriptions of teachers' ideas about the purpose of the new curriculum in terms of skills development were in tension with their use of the concepts of creativity and freedom.

One of the challenges I faced during this analysis was in how to balance the open coding described above with its' emergent sensibilities and tensions, with the already-framed theoretical interest in complexity and how the changing curriculum might be understood as a complex system using the theoretical framework developed in the early stages of the work. My approach to theoretically-informed coding therefore involved re-coding the same data using codes and themes created using the theoretical framework described in Chapters 2 and 3. In this, I adapted an approach from Fereday and Muir-Cochrane (2006), who outlined a systematic method of coding that combined theory-driven (deductive) coding with inductive coding of the data. Their approach, using techniques adapted from Boyatzis (1998) and Crabtree and Miller (1999), involved the development and testing of a coding manual based on theoretical ideas, followed by 'additional coding' which codes data that is not sufficiently described using the theoretical coding manual. I felt that this approach could be adapted to help me 'find a way of reconciling the open coding work already done with the notion of coding from theory, using codes informed by complexity theory and the theoretical framework developed for the research.' (research journal, 9/7/11), and could resolve my problem of how to manage the coding of the data in a systematic way that is informed by complexity theory, without losing the intricacies,

richness and complexities of the data. The coding manual created is shown in Appendix 8. I used this manual to explore the data for the teacher participants. During this part of the coding process, I found that within the data I had collected, it was challenging to use all the different elements identified in the coding manual, and I found it more helpful to focus on the key ideas of 'emergence', 'mechanistic' and 'complexity reduction'. In exploring the data in this way, I found that these key ideas from complexity were apparent across the range of more descriptive codes identified in the data through the open coding process. In Chapter 6, I base the structure of the analysis and interpretation of the findings presented on the final coding scheme created from the open coding phase of the process, and explore the tensions within each of these from the perspective of complexity theory as identified through the theoretically-informed iteration of the coding process described here.

The final aspect of the process of analysis undertaken in this study was the matrix analysis mentioned above, which was used to explore within the data the relationship between complexity theoretical concepts and the concepts from social theory identified in Chapter 3. The idea of matrix analysis, in which a rectangular matrix is used to compare different aspects of the data, can be used in a number of ways to explore aspects of the data (Miles and Huberman, 1994, Richards, 2005). I developed matrices in which mechanistic change/complexity reduction and emergence were plotted against conceptualisations of power, agency, identity and reflexivity in a theoretically informed analysis drawing on the key ideas discussed in the theoretical framing of the thesis. I used these matrices to explore where tensions could be seen in each participant's articulation of their experiences related to these concepts by creating a separate matrix for each participant. Drawing on the notion of the networked collective, I also created matrices for groups of participants, representing OM teachers as a group within one matrix, and science teachers as a group within another. In these, I colour-coded the data represented in the matrix so that the participants within the group could be identified. An example of an individual matrix can be found in appendix 4. The use of these matrices allowed a further layer of analysis and interpretation which supported the development of the ideas discussed in Chapter 7.

4.3.4 Ethical Procedures

In section 4.2.6, I outlined a case for a responsive ethical stance in complexity-based research. I argued for an ethical approach which made use of the rules and guidelines for

ethical educational research, but also maintained an open stance towards uncertainty and the need for ongoing ethical responsiveness to the emergent case. Given the uncertainty of the future, and the uncertainty of the way in which my actions might influence the participants and others in the school, I needed to be able to make decisions about my actions based on the present situation in which I found myself – I was unable to predict all of the ethical issues I might encounter. Pring (2000b) considers ethics as a form of practical judgement based on deliberation on principles and values which may be in contention with what is deemed necessary to seek new knowledge (the purpose of research). The decisions made by the researcher in each case are unique to that case, but can be guided by principles such as informed consent, anonymity, and the need to be open to alternative interpretations. In conducting the research, I took the view that the guidance offered in philosophical approaches to ethics such as Pring's, and by professional bodies such as the British Educational Research Association (BERA), could provide helpful principles in relation to respect for participants and their safety. Even though I could not be certain what the outcome of my actions would be, I sought to act *in the moment* in an ethical way.

I therefore worked with the BERA guidelines for ethical conduct (BERA, 2004) and the code of good practice for ethical research of the Graduate School of Education at the University of Exeter to consider how I would address the ethical issues that I felt would be likely to arise. Engaging with this process involved completion of a document outlining the ethical approach for the study, which was checked by my supervisor and the School of Education's ethics committee. In this document, I explained that due to the nature of research, ethical 'approval' would be an ongoing process and that I would continue to seek the advice of my supervisors if further, unanticipated ethical questions arose. In reality this occurred occasionally. For example, when I realised that one participant had such a unique role that it would be difficult to avoid identifying him in the research report even if a pseudonym was used. This participant was the only teacher who had, at the time, taught both science and Opening Minds. On the advice of my supervisors, I explained this to him and he chose to continue to participate in the research. An electronic copy of the certificate of ethical research approval sent to the School of Education's ethics committee is included in appendix 5; I have kept the signed copy. I was also requested by the school to complete a Criminal Records Bureau check for their records, which enabled them to allow me access to

the school without being escorted by a teacher. In conducting the research, then, I made use of standard guidelines which included making sure that I sought informed consent from participants, including parental consent for students to engage in the research. I gave assurances of anonymity and confidentiality in reporting the research. This included making it clear to students that their comments would be kept confidential (unless they disclosed something which involved criminal activity which I would be obliged to pass on), and that I would not use their names when reporting the research or discussing it with anyone else, including their teachers. All participants had the choice over whether or not to take part, and had the right to withdraw at any time. This had an impact on the sample I was able to reach, as some teachers preferred only to talk informally rather than in a recorded interview.

As part of my ethical approach in this research, I took care to be clear with all the participants about my research interest and what I was doing in the school, particularly because of the fuzzy boundaries around my role as a researcher given that I also knew the school through my role as a teacher educator and personally through my partner and because I live in the community which the school serves. Some of the teachers who participated with me in the research had previously been student teachers I had supervised, or were engaged in further study on courses on which I taught. I managed this by signalling that I was in a different role when observing lessons by dressing more informally and by responding to teachers' requests for evaluative comment on lesson observations by engaging in dialogue with the teacher about the lesson without reference to any kind of standards or outcomes. I also took the decision to respond openly to questions from any participants about what I was doing in my research and why I was interested; since I saw myself as part of the complex system, I felt this was a more ethical standpoint than minimal discussion of the purpose of the research in an attempt to avoid any influence on the system, given the notion of relationality in ethics that is a consequence of a complexity approach.

Chapter 5 - Findings: Describing the Case

5.1 Introduction

The curriculum context for this research was outlined in the introduction to the thesis, and the rationale for the study explained. The 'case study' on which the empirical element of this thesis is focussed is the introduction and development of an 'Opening Minds' curriculum within one state comprehensive school in England. The description of teachers' and students' experiences of a changing curriculum in this case study covers a period of four years, with the majority of data collected during the middle two years (see timeline in chapter 4, Table 5 for further details of when data was collected). In creating this account, I therefore draw on teachers' retrospective descriptions of the initial periods of curriculum development, their speculations and plans for the future, as well as their observations, perceptions and feelings about their ongoing work at the time I worked with them. The following two chapters use the data from teacher interviews, student interviews, observations, questionnaires, field notes and other school documentation in two ways: Firstly to describe the case and the curriculum; and secondly to explore themes arising in the data that are linked to the aims of the study and the theoretical framework. In using this structure, I hope to illustrate the way in which my description and interpretation of the case is both grounded in the empirical data collected as well as being informed by theory, presenting a clear warrant for discussion and theorising presented in chapters 7 and 8.

In this chapter, I use the findings from field work in the school to describe the case study and the curriculum trajectory over the period of the research. This description is clearly interpretive in nature and cannot be a complete representation of the case. It will also be informed by my particular interests, and ideas that have emerged through the process of analysis. However, my intention here is to provide information about the participants and their relationships with each other in the context of the case. Although the act of writing about the case is in itself a form of analysis and interpretation (Gibbs, 2011), this descriptive chapter remains close to the data, to allow the reader to 'step into the case themselves' to some extent. In chapter 6, I will move on to explore my analysis and interpretation of the findings, beginning to link the ideas found in the case to the theoretical ideas introduced in the first part of the thesis. In chapter 7, I discuss the findings in relation to complexity thinking and social theory and consider the implications of the exploration of *this* case in

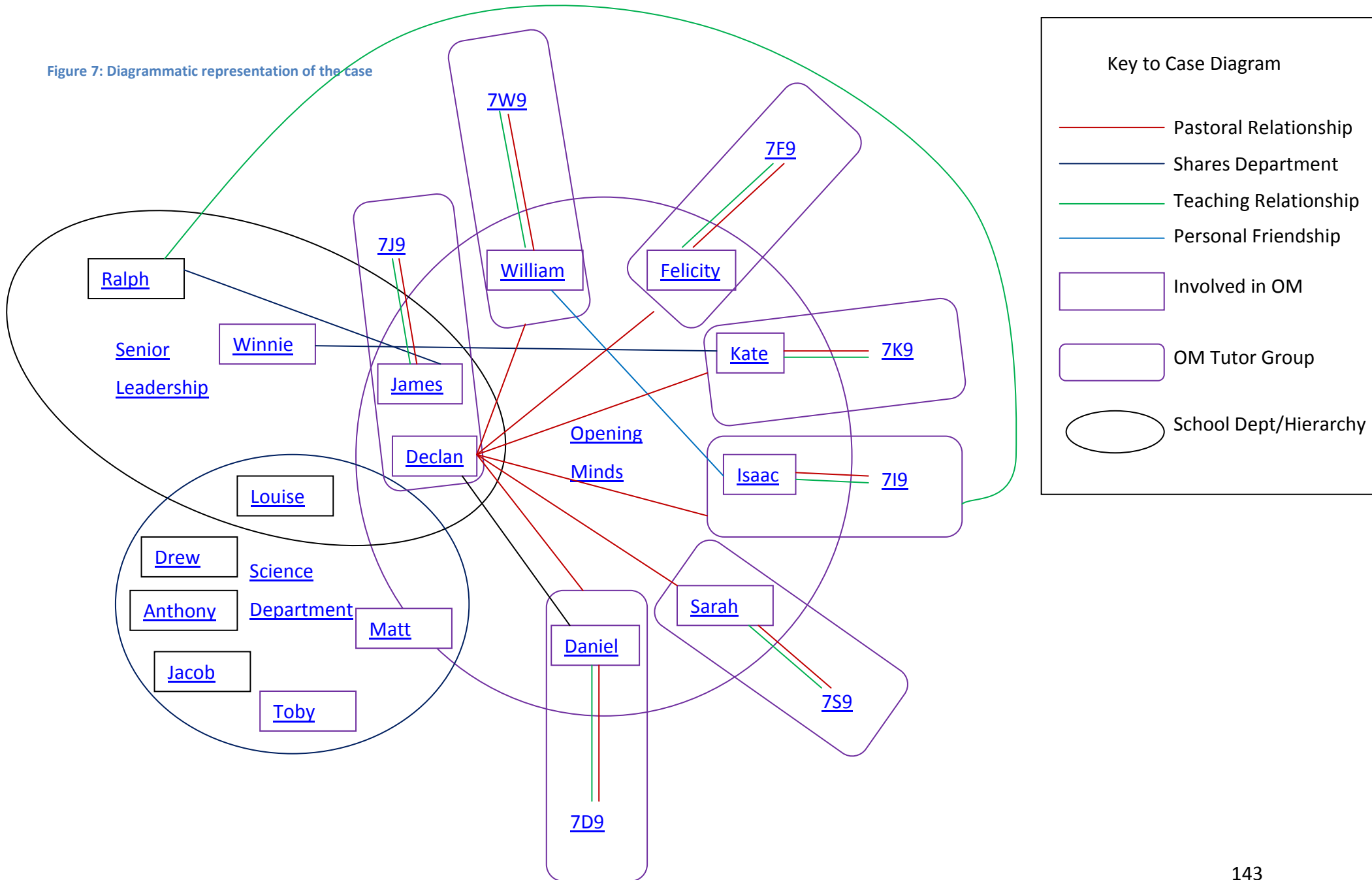
this research for ‘expanding the space of the possible’. In this way, the following three chapters begin with the focus closely on the data and expand outwards to connect the case with wider theory and potentially practical action for teachers.

The presentation of the case in this chapter begins with diagrammatic representation of the case, which draws on representation of cases found in Haggis’ work (Haggis, 2008, Haggis, 2007). In the electronic version of this thesis, labels on the diagram are hyperlinked to descriptions, thus allowing the reader to explore the case and the relationships within it in any order. In printed form, the description of the case must remain in a linear format, but the diagrams offer an alternative form of engagement with the case that is focussed on its networked nature and the interactions. Of course, the diagrams must remain simple in order to be navigable. All names in the description of the case are pseudonyms.

5.2 Diagrammatic interpretation of the case

The diagram on the following page is an interpretation of the case, highlighting the key people and groups that participated in the project, and some relationships between them.

Figure 7: Diagrammatic representation of the case



5.3 Describing the case

For clarity, in the descriptions of the case that follow I have taken the year 09-10 as the frame of reference because it was in this academic year that most of my data was collected. At various points in the description, I will discuss the trajectories in the case before and after this year, up until the end of data collection at the end of the autumn term of the 10-11 academic year.

5.3.1 The School

Bridge Community School is a state comprehensive school for students aged 11-18 which serves a rural market town and the surrounding villages. It is a popular, oversubscribed school with a large catchment area and an excellent reputation in the local community, the wider region and nationally. The school has approximately 1500 students on roll, including 200 in the sixth form (16-18 post-compulsory education). The school has been judged 'outstanding' by Ofsted (the national schools' inspectorate) in numerous inspections, most recently in December 2011, but as Ralph (the Headteacher) says, 'We are always looking for ways to reach yet higher standards'. The school achieves well in the benchmark examinations at GCSE, with results on a consistent upwards trajectory. At the time of the introduction of the Opening Minds (OM) curriculum, there was some concern amongst the senior leadership team that the school's GCSE results did not reflect the consistently outstanding judgements of the school made by Ofsted. In part, the introduction of the Opening Minds curriculum was seen by members of the senior leadership as a way of improving benchmark GCSE and A-level results by improving students' critical thinking and independent learning skills. Since the introduction of Opening Minds, results have continued to rise, although the students who have been directly involved in the new curriculum have not yet reached year 11. As well as Opening Minds, the school is often involved in innovations and is a leading partner locally in 'cooperative learning', regularly sending staff to Florida for professional development as 'Kagan trainers'.

The school site lies on the edge of an affluent market town. The area is relatively expensive to live in, with numerous second homes and a perceived need for more affordable housing for local people to enable them to remain in the area. Despite this, the school intake is seen by staff as 'genuinely comprehensive', with students from a range of social backgrounds. The percentage of children receiving free school meals (an indicator of social class) is below

the national average and the number of children with a statement of special educational need is broadly average (2008 school Ofsted report²⁰). The school is predominantly white, with a small number of black and ethnic minority students and an all-white staff. The school was previously a split site, joining together on one site in 2002. The site is well-maintained and has numerous new buildings with ongoing phases of improvement. At the time of data collection, work began on a new English block.

The school staff have a reputation for being committed to the students and working very hard to give students wide-ranging educational opportunities, including trips, plays, after-school clubs and revision classes (Ofsted report, 2008). The teachers in the school span the full range of experience, with many experienced staff who have been at the school for many years as well as newer teachers: Whether experienced or not, the teachers tend to be passionate about their work and proud of the achievements of the school and its students. When arriving in the school foyer and reception area which is a hub in the school, I was immediately struck by the friendly buzz as teachers and students come in and move around the school. It feels like a happy, confident place.

All the OM lessons I observed took place in classrooms in the main school building. These rooms are light and airy, with large windows and display boards. Often an unusual slightly triangular shape, all the rooms for OM were equipped with interactive whiteboards along with a normal whiteboard to one side which usually had headings displayed for 'lesson objectives'. One display board in each classroom is set aside for the tutor group using the room and these displays often included photographs, notices, rules and achievements. Other display boards showed work from Opening Minds and from the subject area usually taught in the room. All also had cupboards or a cabinet for exercise and text books. In terms of layout, the classrooms were often had a 'teacher desk' at the front in the middle or to one side, with the other desks in rows or in squares at which pupils could sit in groups of four. The latter layout is recommended for cooperative learning activities that are part of the vocabulary of the school, but some teachers clearly prefer to have the students in rows and facing the front.

²⁰ Ofsted reports on the school have not been included in the reference list to maintain anonymity.

5.3.2 The Opening Minds curriculum-as-planned

The change to the National Curriculum for Key Stage Three (KS3; ages 11-14), published in 2007 for implementation in 2008, provided the opportunity for teachers to do something different in their schools. The previous incarnation of the curriculum had specified a great deal of content to be covered, with students assessed in the core subjects of maths, English and science during National tests (colloquially known as SATS) at age 14. The new curriculum focussed more on skills than content and was designed to enable schools to adapt their curriculum to suit their particular context and needs (QCA, 2007c). At Bridge Community School, a decision needed to be made about how they would respond to the change,

One of the things in the new (national) curriculum is that there's twenty percent less content so that was where this came from, really – we thought, 'what are we going to do with this?' (Winnie, Assistant Head and line manager of OM initiative)

Individually, teachers across a range of subjects in the school felt positive about the change to the national curriculum and the opportunities that might be fostered through less specified content and the consequent feeling of extra time and freedom to do things that couldn't previously be squeezed in. For example, the perception in maths was that a change of emphasis towards skills rather than content would allow greater freedom to make maths fun,

Yeah, we liked the changes, we liked the fact that there was less content and more emphasis on processes and skills...the big signal I took from the new KS3 curriculum was freedom – they seemed to be saying: you've got to get kids to enjoy maths and understand the historical and cultural context of maths. It's all about what you can do and the skills you've got and the processes rather than your recall of formulas. (Samuel, Head of Maths)

However, although some schools took the decision to allow different subject areas to make use of the extra time in their own way, the leadership at Bridge Community School decided to use the time in a different way, as noted by Isaac,

Well, overall I'm fairly positive (about the change to the national curriculum) in terms of the history side. Which is obviously what I can talk about. Which has freed things up a bit in history. But I'd say it frees up to give you more time but of course that time has been taken up by Opening Minds. So that's how that worked, the initial thought was 'oh great, we're going to have more time to do this', but of course that time that

was freed up was taken away for the Opening Minds. (Isaac, History and OM teacher)

In order to help them choose what to do with the time available to them, the Leadership Team at Bridge Community School set up a working group, led by Winnie. As Toby described it, this focus group included representatives of each departments,

...and we had this wonderful opportunity where [we were] going to have this inter-combined curriculum...and we came up with different models, visited different schools and the idea being we would run a course in Y7 where they learned skills that were then going to follow them all the way through school. (Toby, Science teacher)

The group then went on visits to find out about what other schools were doing at KS3 and to decide on a course of action that they could put in place from September 2008. The working party consisted of volunteers from across the subject areas in the school, including Daniel, Isaac and Toby (all participant teachers in this study). The teachers on the working group were taken off timetable to visit schools both nationally and in the local area to take note of the different programmes and structures at KS3. Reporting back on the range of examples seen, it quickly became apparent to the teachers that schools were responding in different ways. Some schools were collapsing KS3 into two years rather than three, in order to spend longer on teaching GCSE subjects. Others were keeping KS3 the same length and making the most of the loosening of prescribed content,

Some schools took the line of – we'll teach it at a slower pace, and there's nothing wrong in that because actually it would allow them freedom to go off and do the things they are interested in and have a bit of fun so that is fine. (Winnie)

Still others were shifting the focus from content to skills and teaching through topics rather than subject areas to varying degrees. One local school had moved year 7 onto an entirely topic-based curriculum, but the perception of the teachers at Bridge School was that this was a step too far and not successful enough to be a model to follow themselves. They preferred a model in which there was an element of topic-based work focussing on learning skills, whilst maintaining discrete subject areas at KS3. They were interested in learning skills programmes, and 'flirted' with Alistair Smith's Accelerated Learning before deciding that it 'didn't really hit the buttons of what we were doing' (Winnie). Eventually, they went to a presentation about the RSA's Opening Minds initiative and decided that this was the way forward,

And I went to an Opening Minds presentation and...Jackie Beere was at the heart of Opening Minds and thinking: how actually do children learn? What do we want our learners to be like in the end? – instead of a sausage machine of 2 hours maths, what skills do we want them to have when they leave? She piloted some projects – we were blown away by Opening Minds, we thought it was the way to go, definitely. (Winnie)

When asked why they decided to shift away from the traditional, subject-based curriculum that had previously been in place in the school, Winnie discussed with me the need to respond to the changing student population and changing society, and also the need to develop students as independent learners to prepare them for the 21st Century.

It just seemed – well, one of the things we have been struggling with here for a long time is creating independent learners. We get good exam results, we have happy children, we get generally good parental support, it's a fantastic school to work in – but what we were finding is when students got...into the 6th form and they still didn't really have any independent learning...they didn't really know how to plan an essay, they weren't very good at working cooperatively with other people and we thought, 'there's something wrong here we've got to try and get back to the basics of what we think learning is about because – are we really preparing these people to live in the 21st century?' Which was what we did a lot of when we talked to the staff: what do learners need? And the Opening Minds seemed to provide that fundamental: What do we want these children to be and know as adults and be capable of doing? (Winnie)

In the initial phases of curriculum change, then, there appeared to be a great deal of freedom for the school to make their own decisions about what they wanted to do in developing the curriculum for their students, and, as the quote from Winnie illustrates, the decisions they made were based on both an analysis of what they felt was effective in the other schools visited, but also on what they really felt teaching, education and learning is about. I will return to this theme of teachers' beliefs about education in chapter 6.

Having bought in some OM materials developed by the RSA, the team didn't feel they did what they wanted the curriculum to do so they started essentially from scratch in designing a curriculum based on the Opening Minds principles and competencies (known as CLIPS). In its first year, the OM curriculum was scheduled for the equivalent of one day per week. Some classes had OM for one whole day, others for different sequences of double lessons, but the idea behind the timetabling was to enable classes, populations or the whole year group to be joined up at times and for there to be flexibility in the activities undertaken. A number of subject areas 'lost' lessons so that this time could be given to OM, on the

rationale that the content in the national curriculum had decreased and so the time could be afforded. Religious Education was removed from year 7 and placed solely within OM, and geography, science and English were all listed to me as subjects that had given time to OM. As part of the negotiation within the school in introducing the new curriculum, OM needed to be taught through some of the content or skills that would have been covered in the individual subject areas who had ‘given up lessons’, including science. I discuss the details of the science aspect of this negotiation in chapter 6. These subject departments were approached by Winnie and the OM team to identify if there was anything they particularly wanted to have included in the OM curriculum. The team then met together during two ‘away weekends’, during which time they planned a general skeleton of the half termly topics that would be included in Opening Minds, and worked on adapting the RSA Opening Minds ‘CLIPS’ competencies into language they felt would work for their students. They also decided which pairs would be responsible for writing which topics, with Winnie and Declan working on the first topic, ‘Learn 2’, which Declan described as ‘*almost pure OM*’, introducing the learning skills that were to be applied and developed through the rest of the topics. The topics they created had some sense of particular subject areas related to them, but part of the rationale for Opening Minds that the OM teachers adopted was that it would be useful for students to break down the barriers between subjects, leading to a topic-based rather than subject-based curriculum structure of OM. The topic areas for the OM year are shown in Table 7, and the Opening Minds competencies around which the curriculum was built are shown in Table 8.

Table 7: List of OM topics, adapted from the document 'Keep and Open Minds', a report on OM produced by Declan for staff at Bridge Community School.

Timing	Topic	Includes	Created by
Autumn first ½ TERM	LEARN 2	Learning theory, brain, learning styles...	Winnie and Declan
Autumn second ½ TERM	WE CARE A LOT	Community heroes, healthy eating, bullying...	Freddie
Spring first ½ TERM	IT'S NOT UNUSUAL	News Media, Elections, Opening Minds TV...	James and Isaac
Spring second ½ TERM	IMAGINE	Tribal religions, Land Matters Permaculture trip...	Previous Head of RE, left prior to research beginning.
Summer first ½ TERM	WONDERFUL WORLD	Environment, Sustainability, problem solving	Daniel
Summer second ½ TERM	WALKING ON SUNSHINE	Olympics theme, challenges – creativity, sports, teams...	Matt and Sarah

Table 8: The 'CLIPS' competencies underpinning the new Opening Minds curriculum

'CLIPS'	Description of the Competency	
Citizenship	C1	You can explore and develop your own values
	C2	You understand how you and other people contribute to communities
	C3	You understand why people have other values and customs
	C4	You are aware of how other peoples' lives are affected by technology
Learning	L1	Use a range of learning styles and know which ones best suit you
	L2	You are able to think logically and laterally
	L3	You know what your creative talents are and how best to make use of them
	L4	You understand how enjoyment and curiosity contribute to successful learning
	L5	You aspire to high standards in literacy and numeracy and understand their importance in all learning
	L6	You aspire to high standards in handling information and communication technology and understand its importance in all learning
Managing Information	I1	You can use a variety of methods for finding out, understanding and evaluating the usefulness of information
	I2	You understand the importance of reflecting and questioning information and are able to do this
Relating to People	P1	You are able to successfully relate to other people either one to one or in groups
	P2	You can successfully act as a group member or leader in any situation
	P3	You can co-operate with others
	P4	You can recognise and manage your own and others worries and pressures
Managing Situations	S1	You are able to develop your own ideas and plan how to achieve them
	S2	You understand about and are willing to take risks
	S3	You are able to manage your own time and keep to deadlines
	S4	You understand how to adapt strategies for different situations
	S5	You understand the importance of being able to enjoy success and manage disappointment

In its first year of implementation, the first topic of Opening Minds was developed before the beginning of the academic year, with work continuing on the rest of the curriculum throughout the year as the pairs of teachers responsible for each topic area were given some extra off-timetable time to work on the development. Declan, the year 7 and 8 team leader, also took responsibility for leading the Opening Minds curriculum in the first year of implementation before handing that to Daniel from the second year of Opening Minds. This process meant that OM teachers were often teaching lessons and with materials which they had only recently received, which at times made it difficult for them to plan ahead but enabled the teachers to respond to the students' responses to the curriculum as its development continued.

The second year of implementation of Opening Minds, which was the year in which the majority of data in this study was collected, saw some changes to the Opening Minds team and timetabling. Although the structure of the curriculum remained relatively similar, the science element that had proven problematic the first year through was minimised (see section 6.4). The timetabling was also altered so that OM was not scheduled to take place in such long chunks of time, as teachers had found it stressful to be engaging with OM with their tutor group for half-days or whole days, because the style of teaching was different, because it was new, and because for some, it was tiring to be with the same group for long periods without a break. In chapter 6, I discuss some of the changes to OM that occurred

throughout the data collection in the context of the themes that emerged as important in interviews with the teachers and in relation to complexity thinking and social theory. The above description provides initial context and background, explaining the introduction of Opening Minds and something of how it works: In the interpretation and analysis of chapter 6, details about the purposes and pedagogy of Opening Minds are drawn out from the data in relation to the focus of this thesis.

5.3.3 The Opening Minds Team

The Opening Minds team saw some changes over the period of the research, and the team described here was in place during 09-10, when most of my data was collected. Where necessary, I have highlighted in the descriptions below any changes in role during the period of the research.

Declan

Declan is a year head (a pastoral leadership role), with leadership responsibilities Opening Minds. Other interviews suggest that he is regarded as an experienced, popular teacher with an excellent reputation. He talks passionately about his subject and about teaching, and sees content as having an important place even in a skills-driven curriculum such as Opening Minds. He is passionate about OM as a different style of curriculum and is keen to keep it innovative and fresh. During the second year of Opening Minds, during which I collected most of my data, Declan shared a tutor group (7J9) with James.

Daniel

Daniel, a relatively new teacher, took over a leadership role within OM part way through the project, and continues to work closely with Declan. Data suggest that has a relaxed relationship with his students whilst still maintaining an air of authority. Daniel sees OM as an extremely important initiative in the school and is keen on the learning to learn ideas drawn out through OM. He is convinced that OM is important for developing the skills the students are going to need, and works hard to keep developing the initiative through learning from other schools.

James

James was involved with OM from the beginning and was appointed to the senior leadership team in the school with a particular brief for cooperative learning strategies in the school and initiatives including OM. An experienced Kagan trainer, he is interested in ideas about learning and neuroscience and how these can be adopted to help students learn better. As part of his role, James leads the OM element of the in-school continuing professional development and, as with other OM teachers, is a passionate advocate of the initiative.

Kate

Kate joined the OM team in its second year. She talks with enthusiasm about OM and how pleased she was to be asked to join the team. Data suggests that she draws on informal knowledge about OM in her planning and teaching because she is also a parent within the local community. She is keen to make sure that although the curriculum is different, the students also have some structure and all make progress.

Sarah

Sarah regularly identifies herself as a subject teacher first and foremost, and this appears to be a stronger part of her identity as a teacher than her OM teaching. Interviews highlight that she tries to bring strengths from her subject teaching in to her OM teaching, including practical approaches to aspects of OM. One of the main aspects of being an OM teacher that Sarah values highly is the relationships she is able to build with the students she teaches. Sarah is an experienced teacher and has taught at the school for several years.

Felicity

Felicity was involved in teaching OM from its first year and speaks of her enjoyment of the contrast between OM teaching and her subject teaching. She is an experienced teacher who has been in the school for a number of years. Felicity's students speak of her as 'firm and fair'. I was unable to interview Felicity one-to-one to discuss her ideas about OM as she was regularly involved with other responsibilities.

William

Interview and observation data create an impression of William as caring and thoughtful, valuing the relationship-building aspect of OM. He described himself as 'evangelical' about

OM, seeing a great deal of value in it, but finds it difficult to translate into his subject lessons. He is energetic in lessons, 'performing for the kids' and using his own energy to enthuse and motivate the students.

Isaac

Isaac is an experienced teacher and well-established member of staff who values the importance of good relationships with the students he teaches, exemplified in the data by his taking part in charity events with his tutor group. He was involved in OM 'right from the start' and discusses his enjoyment of the challenge it gives him in trying to teach in different ways. He particularly values that the number of lessons per week devoted to OM gives him the opportunity to get to know his tutor group 'better than ever before'.

5.3.4 The School Leadership

The school has a leadership team that includes a Headteacher, a number of Deputy and Assistant Heads with a range of responsibilities, and others with particular leadership roles such as James' responsibility for whole-school teaching and learning initiative such as cooperative learning and OM. Alongside these, there are middle-management roles as Heads of Department and Heads of Year. In my data collection, I interviewed Winnie and Ralph, and provide short sketches of their roles below.

Winnie

Winnie is an Assistant Head with a number of responsibilities, including working with the OM team. She played a key role in the early development and creation of the school's OM curriculum, working on the 'Learn 2' scheme of work with Declan. Winnie works closely with Kate in her subject department.

Ralph

Ralph is the Headteacher of the school and has a very clear vision of the forward-looking and successful school he wants the school to be. A hands-on Head, he teaches some classes including a Year 7 tutor group during the main period of data collection. He regularly observes lessons around the school and takes an active interest in the teaching and learning taking place. Ralph sees putting together, supporting, and having high expectations of an

excellent and committed staff as a key part of his role. He is keen for Bridge School to be involved in initiatives 'at the cutting edge'.

5.3.5 The Science Department

The science department at Bridge Community School is located in one of the older school buildings, with a set of science labs at the end of a long corridor with a large science office next to a prep. room, a second specific science building containing both chemistry and physics labs, and two sets of prefabricated buildings surrounding a sports court, giving a sense that the department is rather separate from the rest of the school. The department is large and successful, led during the period of research by a confident and experienced biology specialist teacher who retired in July 2011. The department has specialist teachers in all three areas of science, and positions of responsibility are held within the department by teachers looking after Key Stage 3, Key Stage 4 and each of the specialist subject areas at Key Stage 5. Members of the department have been involved in the specialist training in cooperative learning that the school supports, and the department has a sense of dynamism and energy. Two teachers in the department have been involved in leading continuing professional development courses for the Specialist Schools and Academies Trust (SSAT), as Bridge Community School is a specialist school in science and maths.

Matt

Matt has some middle-management responsibilities within the science team and was a member of the OM team, before choosing not to continue in this role as he preferred teaching science and wanted to focus on his leadership responsibilities in science. A relatively new teacher, he sees himself as friendly but firm and enjoys building practical work and activities into his lessons.

Louise

Louise is a confident and well-established Head of department who sees it as her responsibility to support the science teachers and maintain and develop excellent science teaching to help the students achieve. She is positive about some of the aims of Opening Minds but is frustrated by what she sees as the lack of rigour in assessing the impact of these initiatives. She sees herself as part of a successful team and works hard to maintain a team ethos within the department.

Toby

Toby is a physics teacher and a member of the original working group exploring the new curriculum developments. Interviews show that he feels that OM has not lived up to the promise of the early ideas and ideals, but he remains interested in ideas of cross-curricular working and the development of skills between subjects.

Jacob

Jacob is an experienced physics teacher who sees himself as relatively traditional in his approach, and he takes his responsibilities seriously in terms of teaching his subject, being well-organised and providing quality feedback to the students. He believes it is important to get to know the students outside of the subject in extra-curricular activities, but remains sceptical about Opening Minds.

Drew

Drew has a reputation in the school for being outstanding and innovative. He is involved in training teachers in 'dynamic learning' both in-house and nationally, and constantly develops different approaches to teaching, using lots of games.

Anthony

Anthony is a relatively new teacher. He has a PhD and worked in industry prior to teaching. A very confident teacher, observations suggest that he is happy to have a relaxed manner with the students and use humour to develop good relationships with them.

5.3.6 Year Groups and Tutor Groups

The teachers in the study tended to characterise the year groups, and their tutor groups, in collective styles and respond to these, as well as to the individual students with whom they worked. As I will explore in more detail in chapter 6, the first cohort of students to take part in Opening Minds in 08-09 were seen as more confident and more likely to engage in discussion (and naughty behaviour) than the cohorts that followed them in 09-10 and in 10-11. Alongside these types of year group characteristics, teacher looked at groups of students in terms of ability in relation to their response to Opening Minds. In the following, I provide a brief discussion of the tutor groups I observed in 09-10 in relation to the teachers and students interviewed.

7D9

7D9 are cheerful and appear to enjoy group activities, working happily in groups set up by the teacher or with their friends. In this tutor group, I interviewed Julie, a bubbly, confident and 'able' student who embraced Opening Minds and Bridge Community school, and Joshua, an active and chatty student of middling ability.

7J9

7J9 didn't appear to have 'gelled' quite so well as some of the others and there were some apparent tensions between members of the group particularly in relation to two students in the class. In this group, I interviewed Carlie, a middle ability student who enjoys OM because it allows her to chat with her friends, and Steve, a less able student and a bit of a 'loner' who thought very carefully about the answers he gave to my questions and was positive about OM.

7W9

This tutor group were conscientious in their work and responded well to their OM tutor, who encouraged them to look out for each other and particularly a student in the group with a particular special educational need. They appeared to enjoy working on activities individually and in small groups or as a whole class. In this group, I interviewed Callie, a rather serious, mature and able student.

7S9

7S9 had a group of confident, bright girls who appeared to take the lead in class activities. The group appeared to work well together and with their tutor, who encouraged them in working together and in creative activities in group work. In this tutor group, I interviewed Oscar, an extremely articulate boy who was rather academic, and Isabelle, who talked to me about how she was settling in to Bridge and in to the tutor group.

7K9

7K9 had the reputation of being one of the 'naughtier' ones in the year group, who were more likely to question the teachers' expectations in other subject lessons than some of the others. A lively group, they responded well to their teacher in the lessons I saw and

appeared to enjoy the freedom of OM. I was not able to interview any of the students in this tutor group one-to-one for reasons of timetabling.

7F9

The adjective most commonly applied to this tutor group, by themselves and by other teachers, was 'friendly'. Their tutor spoke warmly about them although she also warned me that they could be noisy. I interviewed Cameron from this tutor group, a popular, sporty and confident student who came across as interested in lots of different aspects of schooling but less fond of hard work.

7I9

7I9 were an interesting mix of the studious and the fun-loving. They were enthusiastic about games and about active tasks in lessons but also happy to work quietly on their own. They saw their tutor, Isaac, as 'fun'. I interviewed two students from this tutor group, Zara and Adrian. Both were happy with Opening Minds, although concerned that perhaps they did not get so much from it as from other subjects.

Chapter 6 Analysis and Interpretation

6.1 Introduction

In chapter 1, I sketched some basic information about the curriculum context of the case study that is the focus of this thesis, and in chapter 4 I explained how the data about the case was collected. In chapter 5, I presented a more detailed description of the case, including a descriptive chronology of key features of the Opening Minds curriculum and information about the participants from whom the greater part of the data was gathered. In this chapter, I present and analyse this data in relation to some key ideas and themes that were identified through the process of analysis described in chapter 4. Each of the themes and ideas in the data were generated through a process of open coding, but the presentation here links these themes to the theoretically driven coding in order to consider the ways in which different elements of the curriculum change tie together with a concepts of 'mechanistic' or 'emergent' change. I have also chosen to structure the analysis and interpretation around two broad themes; 'teachers' beliefs about education' and 'ideas about opening minds', and two more specific themes; 'reflection' and 'relationship between science and OM', as these areas reflect the key areas of interest for me that emerged through the data collection and analysis. In the exploration of the data outlined in this chapter, I focus predominantly on data from the teachers' perspectives, as this was my richest source of data and throughout the research I became particularly interested in curriculum change from the teachers' point of view. In part this was because I believe the influence of teachers within the complex system of a school is a useful perspective to consider when rethinking educational action. However, the analysis in this chapter also draws on other types of data in my interpretation of the case. I also highlight areas of tension and difference in the perspectives of different participants and groups which influenced the interactions and the emergent curriculum as experienced in this case. In chapter 7, I discuss in greater detail of some ideas drawn out from the empirical exploration of the case offered here, and link these ideas to the wider theoretical framework and literature relating to the focus of the case study.

Although the presentation of the data in this chapter is broadly thematic, it is important to note that these themes are not exhaustive, and they overlap and interweave throughout. Indeed, the themes identified through open coding were more descriptive than analytical,

reflecting the ideas that were perceived as important about the case in the context of the developing research, meaning that within each 'theme' there are contrasting ideas expressing multiple perspectives. The complexity of the case is reduced by the need to present a coherent and logical account of the data: It is not my intention, however, to artificially turn a rhizomatic structure into a hierarchical one²¹. Attention is therefore paid throughout this chapter to ways in which different themes in the data weave together to build a picture of the case, despite each thread ostensibly being followed separately. Running through the analysis is an awareness of tensions experienced by participants between emergent and mechanistic change and between 'freedom' and 'structure'. These tensions are picked up and explored in relation to the theoretical framework for this work in the final chapters of this thesis.

The analysis in this chapter picks out themes, and the tensions within them, relating to beliefs about education and the purpose of the new Opening Minds curriculum. These themes were drawn out of the open coding phase of the analysis and the implications of these beliefs and their relationship with the curriculum as it was enacted in the case are an important part of exploration of the curriculum trajectory in this case. After exploring these themes within the data, I then turn to look in greater depth at some further themes apparent in my analysis and interpretation of the data that link to particular interactions in the developing case; 'reflection' within the new curriculum, and the interaction between science and OM. Clearly, these aspects emerged in my data as my interests and ongoing analysis wove together with the data through my exploration of the case; as a science teacher, I was interested in the way science related to the new curriculum but this also arose from the teachers' discussions of how OM was changing, making this an area of resonance rather than an 'answer' coming out of my questioning, or an interest that developed from the data in a 'grounded' sense.

²¹ The image of the rhizome instead of the tree has been adopted from the work of Deleuze and Guattari by a number of authors working with poststructural theory, including in complexity and education. See, for example: GOUGH, N. (2006) Shaking the Tree, Making a Rhizome: Towards a nomadic geophilosophy of science education. *Educational Philosophy & Theory*, 38, 625-645, SEMETSKY, I. (2005) Not by breadth alone: Imagining a Self-Organised Classroom. *Complicity: An International Journal of Complexity & Education*, 2, 19-36.. Although I did not employ this as an aspect of my methodology, I am beginning to explore these ideas and find the analogy useful in thinking through the presentation of my work.

6.2 Teachers' beliefs about education

This broad theme focuses on what the teachers at Bridge Community School felt were the key elements of a good education or good teaching. This theme relates closely to the aim of this research for two reasons. Firstly, an exploration of curriculum change must involve consideration of the reasons for the direction of that change as articulated or understood by those involved, as these understandings form part of the feedback within the developing system. Secondly, in the context of complexity theory teachers' beliefs about the aims and purposes of education and the extent to which these can be considered 'closed' or 'open' is of interest in understanding the trajectory of curriculum change in relation to emergence and complexity reduction. The teachers in this case study generally held a relatively 'ends-oriented' view of the curriculum. It was important to them to have a purpose in what they were trying to achieve for their students through the curriculum, whether this purpose be related to content or skills. However, some teachers voiced more open-ended beliefs about what they were doing with their students, for example in expressing a desire to encourage students' questioning. Whilst there were similarities between teachers from different subject disciplines, it was also apparent that there were differences in emphasis and approach between the OM teachers and the science teachers who participated in the study. Categories about teachers' beliefs about education that became apparent in the data include; 'education is about developing skills', 'education is about knowledge', 'education is about developing students' aspirations and helping children realise them', and 'education is about thinking and questioning'. Some teachers expressed ideas related to more than one of these categories during interviews and lesson observations.

6.2.1 Education is about developing skills

In relation to what they wanted the new curriculum to do, teachers commonly talked about the skills that they wanted the students to develop. However, the emphasis on what skills were important and where the emphasis should lie appeared to shift between two concepts; 'developing better learners' (linked to learning skills), and 'developing better people' (linked to life skills and citizenship). Many of the teachers' conversations with me included elements of both of these and there was not always a clear separation between them in the discourse: For many, both were important, with the implication that developing one would develop the other.

Skills for Learning

Implicit in the concept of a better learner is the notion that learning itself is a skill that can be learned, and teachers articulated a range of ways in which students can become better at learning. One of these, already touched on in the description of the case in chapter 5, is the idea of developing independent learning skills. This was viewed as a skill for life that was necessary for children going in to the 21st Century world of work, and a concern that spoon-feeding for exams earlier in the school meant that school leavers and sixth form students were not able to learn independently was discussed by Winnie as one of the driving forces behind the move towards the Opening Minds curriculum (see p. 143). The importance of independent learning was endorsed by Declan; when asked about what he thought good education and good teaching were about, he gave the following answer,

I think you end up sort of having to use jargon and [good teaching] is about being a facilitator. That, you know, when they eventually get into the 6th form and some of them want to go on to university, college, higher education, they are only going to be successful if they are independent learners...But I think a good teacher is putting the student in a position where they feel they can succeed. (Declan)

This excerpt illustrates a distinction between ideas about good education (with the aim of developing independent learners so that students can be successful) and good teaching, which is about the teacher's relationship with the student, acting as a facilitator and helping them believe they *can* succeed. This latter point will be followed up later, as this notion of raising aspirations was also identified elsewhere and formed a separate category in the data. Returning to the idea of independent learning and the development of learning skills, the importance of independent learning in the teachers' thinking about education in development of the new curriculum continued to come through the data for the duration of the project. Indeed, later on when the time came to try to foster use of ideas in OM more broadly amongst staff, the idea of OM developing learning skills was one of the main 'selling points', illustrated in this extract from field notes taken during a training session with staff.

James and Daniel give an intro to what the session will do, showing ideas that have been done with the students...they start with the comfort, challenge, stress zones... J: 'These are transferrable skills, not to be kept in OM. We want you to help with that. We want students to be independent learners.'(Field notes, OM training session 23/10/09)

Exploring what is meant by independent learning during this training session, staff articulated a range of views, including ideas about 'being resourceful', 'being motivated to achieve', and 'confident about discussions'. When asked what they felt prevents students from being independent learners, a consensus developed around the idea that the school has a fear of failure, *'as a school we protect students from failing and that's a barrier to independent learning'*. These comments suggest that although independent learning is valued by teachers as an important part of education that they are trying to foster in the new curriculum, there are a range of different aspects that are seen as contributing to what independent learning is about. Further evidence for this can be seen in an interview with Kate, an Opening Minds teacher whose lesson I observed mid way through the year, when the students in her tutor group were, as she put it, *'great at relating to other people, their peer group – but not so great at relating to, to staff instructions, so relating to others'*. She discussed how the previous topics had included a great deal of group work and team work and she decided to move towards more individual work with them,

Actually they just needed to be more independent learners. Now, in a different sense to the independent learners of being creative and getting on with project work. Being independent as in being able to sit on their own and follow instructions and get on with work on their own. (Kate, OM teacher)

Kate makes a distinction here between independent learning in the sense of being independent of the teacher during their group and project work, compared with independent learning in the sense of independent from their peers and working on their own.

Independent learning, then, was considered by many teachers as a crucial skill to develop in order to be a 'better learner', and was discussed most often by teachers who were involved in the Opening Minds project. However, other learning skills were seen as important, particularly by the science teachers interviewed, and whilst independent learning can be linked to these, the emphasis that came across from these teachers was the need to develop generic learning skills that could be used to aid learning in the different subject areas. The sorts of skills that Toby, for example, envisaged might be involved included,

...things like how to draw a graph, how to measure things properly, how to mind map, how to plan, how to conclude, how to evaluate. Sort of all the things they are going to need for every subject all through college. (Toby, science teacher)

This illustrated the perception that the new curriculum should offer skills that the pupils would be able to make use of throughout college, across subject areas and beyond year 7 all the way through to year 12 and 13. The idea of learning skills that are useful across subjects and could be taught across topics certainly seemed to appeal to the teachers.

I liked the idea [of learning skills] done through topics and that it...it...if you were doing graphs or if you were doing development of description into explanation and so on, that they would be able to do those things and that they would develop those skills during the year in topics. (Louise, science teacher)

The skills discussed here are more specific than the general learning skills exemplified by the notion of *independent learning* and that were ultimately included in the Opening Minds curriculum 'Learn 2' topic (described in chapter 5, Table 6). It seems that while a consensus is apparent in the teachers' discourse about the importance of developing skills in a 'good education', there is much greater variety in the perception of what these skills should be, with the science teachers interviewed holding a more specific view of valuable learning skills when compared with the more general approach that finally appeared within Opening Minds.

Skills for Life

Alongside learning skills, teachers regularly spoke of their belief in the need for students to develop 'skills for life', and this became an important element of the new curriculum. Declan, in describing what he saw as the crucial things students learned in OM, explained, '*It's the old skills for life thing*'. While some of the teachers, particularly those involved in teaching Opening Minds, associated the learning skills described above as important *life* skills, the breadth of skills discussed covered by the notion of 'skills for life' were not universally understood in the same way. Jacob was very clear in his assertion that skills for life were important, but in expanding on this point he listed a range of skills that he felt should be included in the new curriculum that were different in emphasis to those that eventually became the focus,

A good education is young people getting skills that will enable them to develop all throughout their lives. I don't necessarily think we do that now. What they should have done, is Opening Minds should be learn how to read Braille, learn how to sign. Cycling proficiency test. First aid. Basic money awareness. Some proper, useful skills. (Jacob, science teacher)

This was endorsed by Louise, another science teacher who felt that skills such as touch-typing should be included in the curriculum. Instead of focussing on such 'mastery' skills, the teachers who became involved in Opening Minds tended to focus their discussions of the notion of life skills as related to socialisation and citizenship. Daniel nicely illustrates this aim with an example of one of the ways in which he hopes Opening Minds will make a difference,

I think that for me that's what it is – just trying to make better people...Because if you are going to have something called Opening Minds and it's supposed to make you a better learner, you can't just have it in year 7. You've got to have them using it at least throughout the rest of the college...Because that is drawing on what they've learned and it is making them better people and making them more able learners. (Daniel, OM teacher)

I was interested in his choice of the term 'better people', and expanding on this Daniel goes on to explain that he hopes that the students doing Opening Minds will become,

More socially and emotionally aware of their own and other peoples' feelings, able to understand why they feel a certain way and adapt to certain situations...So I think when I say a better person I mean somebody who is aware, independent, motivated, has good values, is tolerant - and lots of other words. (Daniel)

Developing the ability to relate and work well with others, amongst other educational aims, was mentioned by a number of other teachers, including William (who noted the way in which this ability could be developed during his subject time in maths) and Kate, who linked the notion back to learning skills in explaining what she felt was important. It is apparent from these extracts that teachers in this case believe that the development of skills is an important element in education; including both skills for learning and skills for life. It is also clear that the picture of what skills should be developed within the curriculum covers a broad range. Despite the disagreement between OM and science teachers about what skills should be developed, there is a clear perception that the learning of skills is an important purpose of education, which is itself an example of an outcomes or ends-based orientation towards education, which is framed in this thesis as a 'mechanistic' rather than an 'emergent' perspective on education. The teachers generally appear to think of life skills such as the ability to draw a graph or touch-type, *and* learning skills such the capacity to work independently of the teacher, as ends that can be achieved through participation in education. This leads education (and the development of the new curriculum) to be framed

as driven by the need to work towards these pre-identified ends. However, the two different ‘types’ of skills identified in this section *could* be viewed differently through a complexity-informed lens. The ends-oriented lens with which these teachers are working leads to an understanding of ‘learning skills’ that is similar to the ‘life skills’ to be mastered. In this view, learning skills can be seen as a set of closed ‘competencies’ whereas complexity problematises this understanding, as learning is conceived as fundamentally emergent and unpredictable. In chapter 7, I explore the implications of a complexity-perspective on learning for rethinking the learning skills viewed as so important within Opening Minds and how this resonates with the tensions experienced by teachers between this view and their concepts of students’ choice and freedom, using the theoretical notions of temporal-relational agency, identity and power drawn out from the complexity framework in chapter 3.

6.2.2 Education is about knowledge

The belief that education is about developing skills was discussed in more depth in the interviews than discussion of knowledge, I believe in part because of the national trend in education at the time (see chapter 1) and the direction taken at Bridge Community School to introduce a skills-based curriculum. However, teachers also expressed a belief in the importance of content in students’ learning, leading me to create a ‘theme’ for belief about knowledge in education. In fact, the Head of the school mentioned explicitly the need to find a balance between these two aspects,

I think we saw tension between, on the one hand the opportunity to look at skills across the board and look at skills that kids need- personal skills, workplace skills etc- and yet, at the same time, wanting to maintain the strength of individual academic subjects and individual academic teaching. So we saw a bit of tension there, and the curriculum that we’ve ended up with is I think our attempt to resolve that tension. (Ralph, Headteacher at Bridge Community School)

At one end of this scale, perhaps, is Jacob, who talked about the importance of learning facts and expressed a view about the teacher’s role that could be described as transmissive and authoritative. Interestingly, he also associated this with an ‘old fashioned’ approach to teaching compared with the more discursive nature of OM.

So don't you think that at the end of the day, whether we like it or not, education and teaching is still about basic - you're the fountain of knowledge and you've got to get

that knowledge across... You can discuss things as long as you like and have an opinion on everything but if it's not actually right, it's not relevant is it? Maybe I'm just old fashioned like that...There's a lot to be said for rote learning, you know, and knowing facts and details. (Jacob)

It is interesting to note that Jacob was also one of the teachers who felt that skills for life were important, but chose to focus this on mastery of skills such as Braille and money management. The debate about the importance of learning facts and recalling knowledge was also discussed by teachers at the training day for Opening Minds. During this session, one of the leaders of Opening Minds, James, shared with the teachers some information about how memory is stored in the brain. The importance of this was questioned by one of the teachers participating in the day:

12.00 Question from a teacher: "Is recall such an important part of education?" James answers, "Yes, I think it is! I know it's fairly low on Bloom's taxonomy but I think they need it to be able to do other things." Another teacher, "And also for exams". (Field notes, OM training session 23/10/09)

This example shows that although the new OM curriculum focuses to a great extent on skills, some OM teachers believe that learning content knowledge is an important part of education if only as a basis to move on to something else. (The relationship between recall and assessment that is mentioned in this extract is an interesting perspective and is linked to questions I shall return to later relating to the problem of assessment of learning skills.) Declan also expressed the importance of content, so that the skill development is rooted in something concrete,

RE's lost the whole of their curriculum time in Year 7. So it is important that as well as getting them doing the team work and problem solving and all the rest of it...that they also know what some of the main religions actually believe. You know, we've got to make sure they've got some of that. I think otherwise it becomes wishy washy. (Declan)

In relation to education and knowledge, then, these extracts show that some teachers at Bridge School believe knowledge recall is important in itself, and important as a ground for skill development. It is also articulated as important in allowing students to *apply* their knowledge to something new, as suggested by Matt, who described himself as,

A hands-on teacher, I like to teach through experience, analogies and ideas and things so not so much taking ideas and transferring them but giving everyday uses to applications of their knowledge. (Matt, science teacher)

Whether focussing on the transfer and recall of knowledge, knowledge as a basis for learning skills, or the application of knowledge to new areas, the data collected for this project clearly shows that for many of these teachers, knowledge is a key component of what education is for. What the data does not shed light on is teachers' views on how that knowledge is (or should be) acquired, and whilst this is a fascinating question that could be discussed using the theoretical lens of complexity thinking, it is beyond the scope of this thesis.

The importance of knowledge content within the curriculum is a good example of an ends-oriented, mechanistic view of curriculum, in which chosen content is recognised as important and the curriculum is designed to enable students to access this knowledge as the ultimate purpose of their education. Such a view is regularly espoused by politicians as well as teachers and parents. For example, Michael Gove, the current UK Secretary of State for Education, has suggested that,

Teachers possess the knowledge that pupils should aspire to acquire, they have committed themselves to serve others, which is the virtue our society should most prize, and unless their authority is absolute in the classroom then they cannot teach and children cannot learn. (Gove, 2011)

This understanding of the purpose of the curriculum and teachers' roles is firmly rooted in an authoritative, outcomes-oriented view of education and learning that could be seen as contrasting with a complexity-oriented view in which students and teachers work together to learn in new ways and open up new spaces for learning together, through their interactions and relationships with the knowledge and skills within the curriculum. Discussion of later strands from the data expand in greater depth on the tension that the teachers in this case experience between their 'normal curriculum' space of education-for-knowledge and a desire for a more open and unpredictable curriculum space where authority and control is shared between teachers and students.

6.2.3 Education is about raising aspirations and helping children realise them

Alongside the development of knowledge and skills, it was apparent in the interviews with some of the teachers at Bridge Community School that one important aspect of their work was in raising the aspirations of young people in the school. This was an element that was

surprising to me, as the school was generally viewed as successful and is located in an area that is relatively middle-class, with many parents with successful careers and high aspirations for their children. The notion of raising aspirations was touched on in a previous quote from Declan, who talked about good teachers as facilitators to help young people believe they can succeed alongside developing them as independent learners.

The suggestion that teaching is about acting as an enabler to help position the students to believe in themselves is tied to the idea of raising aspirations, and is echoed by Daniel, who believes that the curriculum should help students be able to realise their aspirations and be successful.

I would say [aiming to be] a more able learner who can realise their aspirations, who can understand like: this is what I want to do, this is how I am going to get there. Or say: this is what I want to do, I am not going to be able to get there so I am going to try and do this instead...adapt to certain situations and go: right I don't like doing that so I am not going to do it, but if I have to do it I can do it and I know I can just suck it up and do it.. (Daniel)

Although this element was not identified across the board and the code did not appear in all the OM teacher interviews, it is interesting to highlight for two reasons. Firstly, the teachers who spoke about this area came across as holding strong beliefs about this part of their role, and secondly because of the way the teachers spoke about the students' beliefs and aspirations, with their role as enablers or facilitators who help them achieve what *they* choose, rather than identifying what counts as success for them in advance. As such, this is one aspect of the teachers' beliefs about education that could be viewed as open-ended, in contrast to a more ends-based curriculum approach that looks to develop particular, pre-determined knowledge or skills for the students. However, despite this possible interpretation, the quote from Daniel above, also hints at the teacher maintaining an ends-oriented approach, but with the agency in identifying what these ends or outcomes are lying with the students rather than the teacher. This highlights an area of tension between student agency combined with teacher facilitation, which could be characterised as a more open and 'complex' way of approaching education, and the ends-oriented approach that appears to be the normal view of education. This tension in relation to agency will be explored in greater detail in the chapter 7 through the concept of relational agency developed in chapter 3.

6.2.4 Education is about thinking and questioning

The perception that education is about questioning the world around them, their teacher and their own learning is one of the more contentious areas highlighted by the introduction of the Opening Minds curriculum at Bridge Community School, and as such will be picked up again when I present data related to teacher's perceptions of the Opening Minds curriculum. However, it is important to highlight here as a belief about education that was expressed by some of the teachers and not others, with no clear division between OM teachers and science teachers in this area. For example, Matt, in describing his beliefs about what science education is about, expressed this idea,

I think it's really useful at getting students to think about what is exactly happening...For me, the idea is it challenges misconceptions and gets kids to think beyond what they've just been told. (Matt)

This is a clear expression of the desire to get the children thinking and not simply accepting what they are told and learning the information given to them. This model of learning contrasts with the more transmissive model articulated by Jacob earlier (p. 162). The idea of pupils thinking and questioning for themselves is taken further by William, an Opening Minds and maths teacher who was describing how the maths curriculum might be adapted to help incorporate ideas from OM,

when I do a lesson calculating the mean and do a stop watch exercise and the kids either accept blindly the information I have given them using statistics, or they evaluate it and they question it...that ability to question what's gone up on the board is really important, that's a really important competency (William)

However, despite William articulating his belief in the importance of pupils questioning what their teacher is telling them, which can be linked to a 'complexity thinking' style of approach, his discussion of this as a competency illustrates that his thinking about this is retaining an orientation towards outcomes: Questioning as a skill or competency that students should develop through their education.

As well as questioning what the teacher has told them, or their experiences of the world around them, teachers spoke about metacognition and the importance of getting the students to think about their learning in order to build on it.

[One of the most crucial things they can learn,] would be to...successfully overcome challenges. And then to, even as 11 and 12 year olds, to realise how they've done

that. That it might be their individual strategies but quite often it's a combination of their individual strategies and the skills and strategies of people around them. And...it's not just experiencing success when you've got something tricky to overcome, but it's how did you do it? So obviously that that can be applied again and I think that's the big thing. (Declan, my emphasis)

This notion of metacognition was related to a concept of reflection on learning that was so prevalent in the data it also appears linked to other codes relating to what the Opening Minds curriculum does and how it is assessed. Declan's description of the importance of pupils analysing and reflecting on how they did something is also interesting in that he emphasises the importance of reflection on both the individual student's learning and also the result of interaction with others. This is a much more unpredictable and open-ended notion that is moving towards that of complexity thinking. On the other hand, Declan's discussion also includes the idea that finding successful strategies that can be repeated to achieve success is 'the big thing' which retains the goal-oriented and mechanistic viewpoint seen in other aspects of these teachers' views about education. This code, then, 'education is about thinking and questioning', although apparent to me as a pattern in the data, is particularly interesting in relation to the complexity-theoretical framework of this research because the teachers' discourse does not sit neatly within an emergent or mechanistic viewpoint. Instead, this idea represents a tension with which the teachers are grappling, between encouraging open-ended and unpredictable responses from the students in relation to each other and the teacher on the one hand, and achieving a particular purpose and skills-set related to questioning and metacognition on the other. This crucial point is found elsewhere in the data and will be discussed in greater depth in chapter 7.

6.2.5 Teacher's Beliefs about Education – Summary

The teachers in this study indicated a range of beliefs about what good education and learning should include, many of which influenced the trajectory of the new curriculum. The notion that education should include the development of skills was important to many, although what these skills should entail varied between teachers, with science teachers focussing more closely on particular skills for learning in subject areas compared with OM teachers, who focussed more on the notion of independent learning, learning skills for life and socialisation. Knowledge did not go unacknowledged, though whether knowledge was seen as an end in itself or as a springboard for further development varied amongst the

different teachers. It is not surprising to find discussion of the development of particular knowledge and skills as key elements in teachers' views about education, and often these focus on pre-determined knowledge and skills that are seen to be important, tying in with an 'ends-based' view of education. However, some of the skills discussed by the teachers are relatively open-ended and vaguely defined, and some teachers also talked about building students' self-belief, helping them achieve what *they* want, and the importance of students' thinking about their own learning, questioning their experiences and their teachers. This latter point is an area of particular interest in relation to the aims of this thesis, as it is a site of tension within the teachers' thinking about education and their own role in the classroom in which complexity may afford helpful insights. This idea re-appears in other strands of the data in different contexts and will be explored further in relation to theory and literature in my discussion of the findings from a complexity thinking perspective later.

6.3 Ideas about Opening Minds

Under this broad heading, I want to discuss a range of ideas expressed by the participants through interview and observation in relation to the new Opening Minds curriculum. Through discussion of some categories of ideas created in the process of data analysis, I highlight the tensions between the open-ended (emergent) and ends-oriented (mechanistic) approaches within the new curriculum, continuing the pattern of interpretation and analysis in relation to teacher's views about education discussed in section 6.2. This tension was particularly clearly articulated by one Opening Minds teacher in discussing her role in the classroom,

Apart from when they are actually on task, the planning bit has to be quite structured. So that, it has to be structured to enable them to have freedom, that's how I feel...in order to facilitate their freedom of...creativity, you have to...have facilitated or planned for those – not for every outcome – but so that they are actually free within the creative..I'm not explaining myself very well. (Kate)

Although Kate struggled to give examples or explain precisely how she balanced planned structure with freedom and creativity, the quote clearly shows the tension she experiences in trying to structure and plan a lesson in order to enable the students to express themselves, and also the tension between planning for a given outcome and letting the creative juices flow to see where the students go. This neatly summarises the difficult

balance in the work teachers are doing with their students in the new curriculum that will be explored further in this section, through the views of the new curriculum found during the research.

Ideas about Opening Minds shown in the data were categorised during open coding into the following themes, some of which relate closely to the previous section 'teachers' beliefs about education'. Themes that at first glance may loosely be viewed as tying with a perspective that is linked to mechanistic, ends-based change and complexity reduction are 'OM is about presentations and posters' and 'OM is about transferrable skills'. On the other hand, themes in the discourse that could be viewed as tying in with an emergent perspective include 'OM as different, looser and less constrained', 'OM as breaking down barriers between subjects' and 'OM is about thinking, process and metacognition'. However, these links are not straightforward, as although these relationships seem to broadly fit at first inspection, it is also possible to find examples of mechanistic or emergent approaches within each of these categories as the teachers grapple with tying in open-ended views about what Opening Minds is about with their usual, more linear or step-wise view of learning and curriculum design. The following discussion, therefore, exemplifies each of these categories and shows the tensions between 'structure' and 'freedom' that can be found within them.

6.3.1 Opening Minds is about posters and presentations

This theme appeared in the data across interviews with teachers and students, lesson observations and the questionnaire data. Descriptive in nature, this theme deals with the sorts of tasks and activities associated with Opening Minds, and the sorts of outcomes the students produce. The evidence for this perception of Opening Minds draws predominantly on lesson observations, where many of the lessons observed involved the students working towards an outcome that included a presentation or a poster. Examples included the presentation each group of students within the tutor groups were asked to create in the 'food for thought' sequence of lessons; presentations each tutor group put together for the 'Opening Minds Olympics'; and short presentations each student was asked to share about their research into their ancestors during the 'Imagine' topic. The same emphasis on 'presentations' was also indicated explicitly in conversations with teachers, as illustrated in this example, where Daniel is reflecting on the first year of Opening Minds,

Well that first year they did [a lot of presentations] because it was the first year through and the only scheme of work you really knew was the one you had written and you didn't realise how many presentations there were across the whole unit until you got to the end of the year and went blimey, haven't we got a lot of presentations - you would end one scheme of work with a coming together presentation then you came back after Easter and the first task was a presentation. (Daniel).

This quote suggests that Daniel felt there was an over-emphasis on presentations in the first year of Opening Minds, and this was something he later explains he adapted for the following year. This point is endorsed by Matt, who goes further in suggesting that perhaps OM was not sufficiently academically challenging,

And that kind of idea [referring to specific skills of graph-drawing and other cross-subject skills] would have been good to include as well, and a bit more academically rigorous I think. I think some of the tasks were seen as just, seen by some of the students as we're just filling time kind of thing. We're spending a lot of time doing a poster, or another poster, or another poster. You know, death by poster. (Matt)

Despite this, evidence from the questionnaires conducted with students indicates that the students in the cohorts following the introduction of Opening minds were significantly more likely to respond that presentations were a type of activity that 'helped them to learn' than the students from the KS3 cohort prior to the introduction of OM ($\chi^2=47.413$, $p=0.000$; Figure 8). Whether this suggests that presentations were helpful in learning or just that students recognised them as a more prevalent learning activity is not clear from their questionnaire responses or the student interviews, but this is a further piece of evidence indicating the shift in pedagogy towards presentations and related posters as an 'OM' activity.

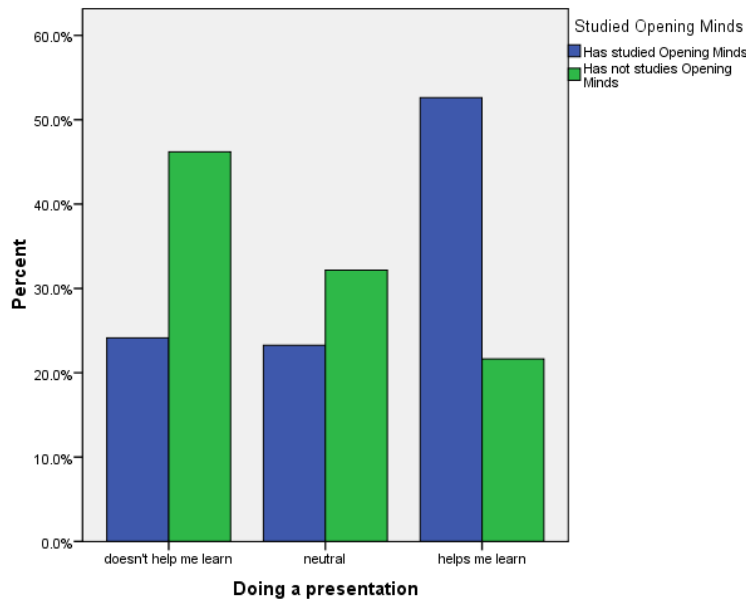


Figure 8: Students who had studied OM were significantly more likely to respond that 'doing a presentation helped them learn'. ($\chi^2=47.413$, $p=0.000$)

There is further indication that the type of activity experienced by the students often related to presentations and posters in the examples that students used when discussing Opening Minds in interviews. In this extract, Cameron is talking about ways of working in groups, and illustrates this with reference to doing posters,

In a group you've got to do what you're best at in that group. So someone might be really good at finding things out on the computer so they'd do that while someone else creates a poster for whatever we're doing, if it was a group where you had to do a poster and find some information out, you know. (Cameron, year 7 student)

He continues to refer to poster work in the sorts of examples he discusses in Opening Minds, explaining how he prefers to work on his own if it is a small A4 poster that is assessed, but if it is a large one for the whole group it is better to work in groups. Cameron's use of posters as examples to illustrate his points indicates that it is a regular type of activity the students in OM engage in.

The following 'tag cloud' image is from the questionnaire responses filled out by the students who had done Opening Minds. A tag cloud is a visual representation of the frequency of words in a piece of text – the more frequent the word, the larger it appears on

about one of their ancestors, bringing in props or using a writing frame that had been provided for the homework. The students then gave their presentations in various formats, but the use of the presentation appeared to be both open-ended, to explore the students' ideas, and relating to some objectives in the lesson which were to understand the importance of notions of ancestors in their own and others' cultures. The way in which teachers interact with students in open-ended ways, whilst at the same time working to direct the lesson towards particular objectives, is a balancing act that is interesting to engage with from a complexity perspective. Again, this is a thread I shall return to in greater depth in chapter 7.

6.3.2 Opening Minds is about transferrable skills

In discussing 'Teachers' beliefs about education' (section 6. 2), I noted that many of the teachers interviewed were clear that the development of skills was an important part of what the curriculum should include, whether they be general learning skills, skills for life, or specific skills that can be used across subject disciplines such as graph-drawing. Unsurprisingly, this is echoed in the data describing the Opening Minds curriculum and is therefore included as a category here. As highlighted in the previous discussion, the importance of transferrable skills in Opening Minds was made explicit by Daniel and James in their presentation about Opening Minds to teachers at an OM training day,

Daniel: "OM is about teaching students skills that will help them in their learning. Hopefully you can use these in your classes." (Field notes, OM training session, 23/10/09)

That skills are emphasised in the OM curriculum is indicated by the students' questionnaires responses in the tag cloud (Figure 9), where words such as 'group', 'others', 'people', 'team', 'together' and 'cooperate' are significant, suggesting that a key message the students have taken away is related to their ability to work with others in teams or groups. The ability to work in a team is a skill that can be related to learning across school as well as being beneficial for the students in later life. Whether the skill of being able to work well with others is a skill that is an end in itself or whether these interactions can be a prompt for emergent learning, meaning and identity is, again, not always clear in the data and it is possible that it can be seen as either, or both. I interpret the following field note extract as being predominantly mechanistic in nature,

Bumped into Isaac in the corridor. I asked him how the rest of the Olympics went and if his tutor group won. Isaac, "Yes! Well, we won the sports but the great thing is that everyone won something. So each tutor group won something. And they were working as teams." (Field notes, 8/7/09)

Here, although the Olympics was set up as a competition between tutor groups and this is the ultimate 'outcome', the teacher emphasises the team work element. In this case, the teams were working towards a particular goal (winning the competition) so this could be viewed as mechanistic rather than emergent, but this is not to say that emergent learning did not occur. This perception of key skills as goals to be developed within Opening Minds, suggesting that the teachers are regularly working with a mechanistic perspective, is also illustrated by the use of skills-based learning objectives in the curriculum.

Skills appear in the Opening Minds lesson objectives in OM schemes of work, and teachers put them up on the board at the beginning of lessons, which suggests that such skills are viewed as a curriculum outcome which the students should achieve during the lesson. These skills are often related to the CLIPS competencies around which Opening Minds is based and are often rather general in nature. Examples of objectives appearing in observed lessons included 'understand how we learn together', 'understand the roles in a group', 'understand what makes a successful team' and 'be able to think in different ways'. The latter is particularly interesting in relation to the tension between mechanistic and emergent thinking that is a focus for this research, since the ability to think in different ways might imply an emergent perspective and yet it is written down as an objective for the lesson and the lesson which followed was structured around the 'De Bono thinking hats' and so could be seen as rather closed in its aims.

We can see through the students' experiences reported in the questionnaires and in observation of lessons, that skills were a key part of the Opening Minds curriculum that came to be enacted, related to the teacher's beliefs that skills are an important part of education. These skills were explicitly made part of the objectives for each lesson, which implies that they are seen by teachers within a relatively 'ends-oriented', mechanistic view of the curriculum. The way in which lesson objectives are used in the case can be related to assessment and complexity reduction, which I discuss in greater depth in section 7.3. However, a focus on skills of group and team work also allow greater interactions between students in the class, thereby contributing to circumstances that might foster emergence in

terms of curriculum, learning or subjectivity. This is therefore a further example of the complex balance between mechanistic and emergent approaches.

In the introduction to this set of codes, I suggested that the initial two might, on first glance, be interpreted as leaning towards a mechanistic rather than emergent perspective on curriculum change. However, I have shown in the analysis above that when beginning to consider the codes in more depth, these categorisations begin to collapse and the tensions in perspective within each code come into sharper focus. I now turn to the codes that I initially felt represented more open-ended and emergent ideas about Opening Minds, and continue to examine and explore the tensions found in the data explicitly and in the gaps and silences of what is not said and shown in the data (MacLure, 2006).

6.3.3 Opening Minds is different: looser and less constrained

A very clear message that came across from two teachers (James and Declan) was that they wanted the OM curriculum to be 'different' – like nothing else that was done in the school. The desire to be different appears very early on, with Winnie's description of their purchase and subsequent abandonment of the Opening Minds schemes from one of RSA Opening Minds team,

You can buy in the projects and I thought: 'Wow, that's alright I'll have them, that's going to save bucket loads of work.' And they came...and we looked at them and we thought: 'they are so boring!' They were awful...we just didn't like them, it wasn't what we envisaged it being, we wanted it to be a totally different way of learning. (Winnie)

This early sense of a desire to be different might have gone in any number of different directions. A sense of creativity, difference and innovation came across very clearly in conversations with James, and he was the teacher who spoke most regularly about this aspect of Opening Minds. The way in which Opening Minds was seen to be different was related, for James, to a sense of loosening constraints, as indicated in this description,

And there are oddball things they wouldn't do normally, so last year we had live broadcasts, so each group would do OMTV – Opening Minds Television - and they had to prepare this thing and then be filmed live and then it would be broadcast in the other Opening Minds classrooms – we'd never done that before. So if it's shambolic or if it works really well, but it's exciting, it's different. (James, interview)

A live broadcast such as the one James describes here is indicative of a pedagogy that appears to be more open and unpredictable – or shambolic, as James put it. The timetabling and resources for OM were designed to facilitate these sorts of differences, as it allowed the different classes to cooperate or compete with each other in tasks like these, or like the OM Olympics. As well as alterations in terms of timetabling to facilitate innovations such as OMTV, the style of planning and pedagogy appears to have moved towards more independence for the students and fewer constraints, with the teacher ‘leaving the students to it’. The feeling of risk in giving the students more freedom is echoed by Declan, who explains how important it is for the OM teacher to ‘capture the students’ imagination’ so that the students are engaged with the lesson and benefit from the greater freedom,

*I really think there's got to be that element of...capturing their imagination. Because, I mean the fact that they go off in all these different directions and that every little group might be doing things that I as the teacher, I don't know when I'm supervising two groups over here working on a drama, what the others are doing. So if you haven't captured their imagination they will end up wasting time and they will end up drifting into you know, classroom management issues and poor behaviour and stuff. So you've really got to grab them, because they're going to go off and run it.
(Declan)*

Here, Declan balances the need to manage the class with the way in which responsibility for their work is passed to the students, but rather than seeing class management as a constraint on the students, he chooses to focus on the need to ‘capture the students’ imagination’ and help them ‘see the value’ in what they are being asked to do in order to avoid problems. This style of interaction with the students is embracing a more emergent approach, as it still appears to give the students the responsibility for the outcome of their activities through attempting to engage and motivate the students rather than ‘manage’ them and limit their options. I noted this kind of approach in the first OM lesson observation completed. I had arranged to observe one of Declan’s lessons and had created an observation sheet, which I quickly had to abandon as the students were given a set of tasks and then sent off to work on their different tasks, in groups they chose, for the rest of the lesson. They were in and out of the classroom, visiting the library, other Year 7 tutor groups, working in the corridors, visiting the gym, and there was no way the semi-structured observation I had planned could occur, as I couldn’t ‘follow’ particular students within the class – and neither could Declan, who relied on their initial engagement with the activity to

keep them motivated and cooperating. This surprising lesson early on also left me with the impression that OM is different and less constrained. However, I later discovered that style of lesson was not always consistently adopted within OM, which will be explored further in discussion of the code 'reflection'.

Despite being the teacher who appeared to most strongly embrace difference, James also acknowledged that this difference was not always possible in practice:

In the classroom it's – the idea is that it would be different, ok? The idea is when we started planning it, one of the things we said to ourselves was: if it looks like something we would do normally, then we are not doing it. So obviously that doesn't always happen in practice I would say, because you've got other issues like classroom management so if they come in and they're quite noisy – but the original principle was if it looks like something we would normally do then we're not going to do it. (James)

This extract shows how adamant James is that Opening Minds should not be the same as the normal curriculum, to the extent that whatever is done 'normally' is something to be avoided. At the same time, it shows the tensions that exist for the teachers between the newer, more open style and a more traditional style, as he acknowledges that the need to manage the class at times dictates that 'doing things differently' is not always possible. Declan also shares this sense,

I wanted, I wanted it to be, to be completely honest, I wanted it to be more different. And my concern is that as it kind of settles down and we...I think we wanted to get the basics sorted and I think we've got a really good core curriculum, but I think there are elements in each of the six topics that I think we need to make more different. OM need to be ahead of the game and pushing it. (Declan)

Here, we have a similar sense of a desire for the OM curriculum to be 'different' and not like the traditional subject teaching, but again there is a sense of constraint on this desire to be different. Unlike James, who identified classroom management as a constraint, Declan identifies time for teachers to innovate when they are also working on developments to their own curriculum area. He is also concerned that, as the core of the OM curriculum beds in and is no longer so new and uncertain, some of that sense of difference could be lost rather than built upon. Looking at this from the lens of complexity thinking, one could speculate that the strong habit of mechanistic, goal-based and structured thinking about curriculum gradually mitigates against the open-ended and emergent space that is

exemplified in the idea of 'doing things differently' in a way that feels more creative and free but also more risky and challenging. At the same time, we can see from his conversation that for Declan, there is the feeling that subject areas are catching up on the innovative pedagogy in Opening Minds, and it is important for teachers in OM to have time to stay a step ahead. This is an interesting element of the interactions between teachers and department; in complexity terms, the idea of different innovations in different parts of the system driving development forward could be interpreted as an example of the potential for emergence resulting from feedback and interaction within the system.

The teachers' sense that the new Opening Minds curriculum should be different is clearly shown in the extracts presented above, and given that the difference these teachers are embracing is related to an alteration in style towards more group work, more open-ended tasks and more independence for the students, it appears in the first instance as though the Opening Minds curriculum can be seen as embracing a more 'emergent', open-ended pedagogy. However, despite this being the teachers' vision, they also acknowledge the difficulty they face in maintaining this looser style in the face of classroom management questions, constraints on their time and potentially familiarity with the new curriculum. Informed by complexity thinking, Osberg and Biesta (2008) argue that although the content of the curriculum is important, the curriculum should be more concerned with how that content is engaged with in a responsive way, such that the curriculum *and* the content emerge from the educative situation itself. This argument suggests that teachers engage with any curriculum, including Opening Minds as it 'beds in' to the school, in ways that are actively responsive and oriented towards emergence. In this way, innovation is not so much about the content and pedagogy of the curriculum simply being different to what went before, but instead is found in the ways the teachers engage with the curriculum. The tension discussed by teachers in relation to this 'theme' in the data is an example of the challenges faced in negotiating the tensions inherent in making what are seen as radical changes in curriculum and pedagogy. These aspects of the Opening Minds curriculum trajectory can be explored in relation to concepts of relational agency, identity, power and reflexivity, which I take up in chapter 7. I consider what a change in thinking made possible by engaging with complexity, such as that made by Osberg and Biesta (2008), could mean for teachers actively engaging with these sorts of tensions in a changing curriculum.

6.3.4 OM is about breaking down barriers between subjects

Linked to the suggestion that OM is different and less constrained is another category of ideas about OM: that of OM breaking down subject barriers. The notion of linking subjects together for the students could be argued as allowing richer connections to be made, which is seen as beneficial for the students' learning, both within subjects and in aiding them in transferring skills between lessons. In talking about the initial exploration around the changes to the national curriculum and the development of Opening Minds, Winnie explained that part of their rationale for change was to attempt to link the subjects without losing the sense of distinctive subjects.

We were quite happy with [how the school/curriculum was originally structured], we had tried quite a lot to get departments working together to try and make cross curricular links...but actually when we looked at the national curriculum that seemed to be where it was at – it was everybody in their own compartment...The front covers of the old national curriculum, and the new one; the old one has lots of coloured rectangles on it and each rectangle supposedly representing a subject...when we looked at the new one (and we used this a lot to sell to staff) was that each subject area was a coloured ribbon and they were all entwined together. (Winnie)

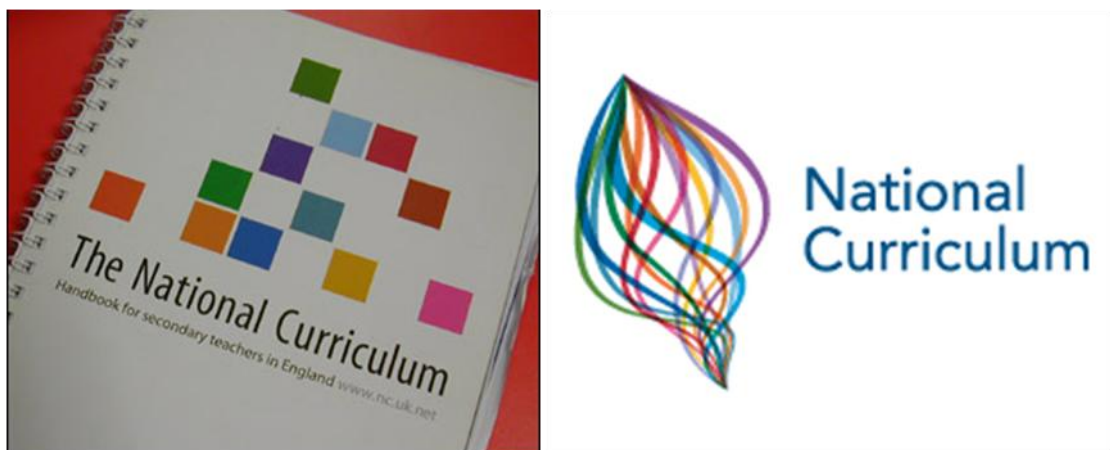


Figure 10: Images of the old (2000-2008) national curriculum and the new (2008-present) national curriculum logo, showing change in representation of subjects as described by Winnie.

Winnie's comments show that they were already considering a desire to foster greater cross-curricular work, but interestingly didn't feel able to do that until the change in the national curriculum, tying with their own questioning, provided a tipping point to move in that direction. Winnie's description of the national curriculum logos (see Figure 10) and their use to 'sell' the change to staff concerned about losing the distinct nature of their

subject demonstrates that at Bridge Community School there was a desire to change but a reluctance to move too far towards a collapsed curriculum. The balance between these two that was found in Opening Minds resulted in the maintenance of subjects whilst at the same time introducing OM as a cross-subject lesson.

The idea that OM is about breaking down barriers between subjects was included in the OM training session run by James and Daniel. As part of this session, James explained the idea of 'subject lenses', used with the students in OM. The idea of these subject lenses is to encourage students to look at a particular topic or idea in a lesson from the perspective of different subjects, with the suggestion that it is also a good way of encouraging teachers to act differently and move away from their normal teaching. The inclusion of this idea in the teacher training for OM suggests that it is a key part of what OM was intended to do, and James expressed a hope that the students would articulate this idea when interviewed about Opening Minds. Disappointingly for James, perhaps, the students didn't volunteer this idea in interviews with me, and the subject lens idea was only mentioned by one other teacher during interviews and observations.

Although the idea of 'subject lenses' appears to have had only a limited impact, teachers' regularly mentioned a hope that OM would foster greater transfer of skills between subjects, and the CLIPS competencies were seen as a way of enabling that. For example, Isaac explained how he used ideas from OM in his history teaching to help students see the connections between what they are doing, insisting that 'it is helpful for breaking down the barriers between departments'. The aim and the desire to foster greater crossing of subject boundaries is clear, but Isaac also indicates that there is still some way to go,

There is a lot more work to be done on getting the kids to realise that they can use opening minds skills in other lessons, there is no doubt about that. And having things like the clips in the planners is absolutely fantastic for that...But the kids are still resistant to the fact that 'well, we did that in opening minds so we don't do it in history or geography'...you know, it's still quite compartmentalised (Isaac)

Both the desirability and the difficulty of enabling the students to link subjects together is echoed by teachers who were not involved in Opening Minds, and who held different perspectives on which transferrable skills would be desirable in the new curriculum. Again, although the details of the skills that would be beneficial to develop and transfer are

different, the argument as to why this is difficult is the same. For example, Toby wants the new curriculum to focus on particular skills such as graph-drawing and evaluation, seen as beneficial in a range of different subjects, but he notes that students struggle to transfer skills between subjects. From the perspective of the science teachers, it seems that the desire that the new OM curriculum would help to cross subject boundaries was fully embraced, but there is also disappointment that this didn't happen in the way they wanted, or that they didn't see the evidence that it had had an effect back in their science lessons. Louise, for example, is very clear that the transfer of skills between subjects is a 'dream', but not one that she saw happen in practice, either as a result of Opening Minds or during the rest of her teaching career. Louise expressed a desire that the curriculum mirrors life in that ideas, knowledge and skills are not compartmentalised, but she also drew on examples that again focus on particular outcomes in terms of knowledge or skills that the students should learn. This is a slightly different example of the tension between freedom and structure, between facilitating links between subjects in a less-structured style and an outcomes-based mechanistic approach to a traditional subject-based curriculum. It is also an example of the sort of complexity reduction discussed in chapter 3, as the resistance found in the case to breaking down subject barriers and fostering greater interaction between subject areas continued despite the expressed desire by OM teachers and others to move towards more cross-curricular work.

The idea that OM should include the breaking down of subject boundaries comes across in the teachers' discourse, both in the OM team and amongst other teachers. However, it is also clear that this has been a difficult area to put into practice, at least in the early years of Opening Minds. In this context, the ideas of relational and temporal emergence articulated in chapter 3 allow the relationship between subject areas and the related curriculum structure and trajectory to be explored in a different way. The concept of 'nestedness' in complexity which is related to the notion of relational emergence developed in chapter 3, is helpful in considering the disciplinary and interdisciplinary nature of knowledge and skills, including some of the difficulties in relating different phenomena from the perspective of different disciplines. McMurtry (2011) explores how complexity theory can be useful in thinking about interdisciplinarity differently, as it engages with both the complexity of the phenomena that are the objects of disciplinary study and with the complexity of the

'knowers' – in this case, the students and teachers. McMurtry builds on previous work exploring the relational and dynamic nature of knowledge, and the idea of complex interdisciplinarity is helpful to apply here. The OM curriculum emerged in part as an opportunity to foster interdisciplinary understanding on the part of the students, encouraging them to make links between different traditional subjects that were also maintained in the structure of the school curriculum. Through the process of writing the schemes of work for OM, the structure of the curriculum that emerged included a mix of interdisciplinary and disciplinary ways of working: The structural (relational) organisation of knowledge, and the associated timetabling, was different and new to the context of Bridge Community School. The notion of 'subject lenses' within the new curriculum can be viewed as a way of engaging the pupils' different perspectives on ideas and offering them different ways of responding to ideas within different educational relationships in and between different subject areas. The relational emergence of the OM curriculum structure may support interdisciplinary thinking. It could be argued that the aim of breaking disciplinary barriers is likely to foster greater interaction of ideas for the students, thereby increasing the complexity of the educative situation and leading to greater potentiality for emergence (both relational in relation to their organisation of knowledge and temporal in relation to the emergence of knowledge for these students over time) in the students' responses.

However, it seems that in this area, there was resistance to this aspect of OM from the students, and subsequently the curriculum trajectory at the level of both OM and the other departments in the school may be influenced towards maintaining the previous disciplinary framework. In their attempts to break down barriers, some teachers attempted to use the CLIPS competencies to help to make these links and pointed out to students where there were connections, but there is little evidence in the data that this was effective or that the students made these links themselves in a more emergent style. This is further evidence for tension and balance between a desire to work in a looser style that can be seen as having greater capacity for emergence and a desire to work towards particular goals (in this case using competencies to make links for the students), which could be seen as tying into a Cartesian perspective. In relation to this aspect of the Opening Minds curriculum trajectory, analysis of the patterns in the data presented here in relation to the conceptual framework developed in chapter 3 affords a different lens on the tensions experienced as the new

curriculum evolved, in particular in relation to teacher and student agency and identity and how this relates to subject-based ways of thinking. Again, these ideas will be discussed in greater detail and related back to theoretical ideas drawn from the literature in Chapter 7.

6.3.5 Opening Minds is about thinking, process, metacognition and reflection

A further category in the data in the general area of ‘ideas about Opening Minds’ is related to the idea of process over content, with those processes including an emphasis on ‘metacognition’ and reflection: in other words, thinking about learning. Reflection as a key part of the new curriculum is examined in depth separately in section 6.4, as this became both a crucial part of the curriculum and key area of interest in the research that also links in to changing teacher practices. Therefore, I present here a broader level of explanation of this understanding of the Opening Minds curriculum. The following quote from an interview with James neatly describes the perspective that this category encapsulates,

On the whole I found [Opening Minds] positive and quite liberating. I like the idea of focussing on process rather than on content, which is not to say the content is meaningless, but it's not always something you get to do say in English, [where]you are first of all bound by a curriculum which is understandable, so that it's standardised I suppose but... sometimes you want to stand back and think of the process, how did we get here, was it a good way of doing it? If it didn't work and it's not finished we can think of why it didn't work and what we can do next time. But I think it addresses, it's about metacognition really isn't it? You don't just do things without realising why you're doing it, and the answer is never just – because it's in the exam. It's a bit more human I suppose? Why are we doing this, what's the meaning of it? Getting them to reflect on why they've done things. (James)

The notion that focussing on process, metacognition and reflection is more human than the standardised, exam-based ‘binding’ curriculum is particularly striking in relation to the tension between a developmental, complexity-reduced view of curriculum and an emergent perspective. James is suggesting here that the subject-based, examined curricula limits the time available for teachers and students to reflect on what, how and why they are learning, which reduces education to the achievement of particular examined knowledge. Changing this curriculum focus to create time to think is a positive and liberating experience for James, fitting in with the beliefs he holds about what is important about education (see section 6.2) and opening up the process for the students.

As with previous categories within this theme, the notion that Opening Minds is about metacognition was presented during the OM training for teachers. The feeling that came across during James and Daniel's explanations of metacognition during this training was that their interpretation of metacognition was to do with encouraging the students' to reflect on what they have been learning and doing, and focus on the processes they have gone through and the tools they have used rather than simply on the content they have covered or the outcome of the piece of work. It is acknowledged in the literature (see e.g. Wilson and Bai, 2010) that metacognition is understood by teachers in a range of ways, which vary in their sophistication. In some cases there is an assumption that metacognition can be incorporated into lessons using particular 'thinking' schemes that can be bought or adopted wholesale. However, the notion of metacognition within Opening Minds appears to have avoided simply adopting one perspective or system, and instead a mixture of ideas about 'learning to learn' was written into the 'Learn 2' scheme. During observations and interviews I noted references to a range of these ideas, including Claxton's Building Learning Power (Claxton, 2002), De Bono's thinking hats (de Bono, 2000), and Gardner's Multiple Intelligences (Gardner, 1983, 2004) among others. Rather than adopting one view of metacognition, rooted in a particular understanding of how metacognition can be developed, the perception that has emerged amongst these teachers appears to be that it is helpful to provide students with a range of tools for thinking about learning, which they can then choose how or when to adopt. This approach is illustrated in the following extract,

Part of the learning is here's this process, so what do we think of this process – so now you've got a tool you can use, if you are going to brainstorm you've got this tool, you've got this tool. Another thing was to give them an element of choice, so if we are doing a task what do we need to do to complete this task? What tools have we got at our disposal, which ones are going to work? (James)

Rather than focussing on a specific way of teaching the students about metacognition, the idea behind Opening Minds was to introduce a range of tools to the students and focus on the processes they have undergone in doing an activity. The emphasis on encouraging the students to make their own choices about the tools they might use and what they make of them keeps this element of OM theoretically relatively open-ended and emergent. It is not clear from the data whether or not this is something that is experienced by the teachers and students in practice, as in some ways the observation and interview data appear to show

the tools that the students choose to use in the later topics (in which the intention was to give students' opportunities to apply the OM 'Learn 2' tools in a range of contexts) are limited and are only used when they are reminded of them by the teacher. On the other hand, students did make reference to having more choice about their activities in Opening Minds than in other lessons. Declan also told me anecdotes about some students who had been attempting to use OM strategies in other subjects. For the most part, however, examples of choice given by students tended to relate to how to practically do a task: In interviews, students did not refer to learning tools or metacognitive ideas from Learn 2 as part of Opening Minds unless I prompted them further with examples.

Although process is identified as an important part of Opening Minds, the necessity of balancing this against content that will engage the students and help them 'see the point' is noted by Declan in the following extract,

And for them to do what they're doing and actually have a chance to reflect on it, which is the whole point of it, that, you know, the process is important and the content has got to be meaningful otherwise they kind of resent it. (Declan)

Similarly to the category 'Opening Minds is different, looser and less-constrained', this category is drawn predominantly from the interviews and observations with Declan and James. The breadth of discussion of process and metacognition as key elements of Opening Minds is limited in the other teachers' comments. Instead, the majority of teachers are much more likely to discuss reflection as a particular process in Opening Minds, giving the impression that 'reflection' as a specific way of approaching metacognition and process over content has been more fully embraced than the broader beliefs about the importance of metacognition held by the leaders of the OM curriculum.

This element of the data in relation to Opening Minds weaves closely with the coding related to teachers' beliefs about education as being about thinking and questioning, reflecting a similar tension between what could be seen as a more open-ended and emergent approach and a more linear, mechanistic trajectory and approach that can act to constrain teachers' practice and reduce the complexity of the system. These ideas will be discussed in more depth later, as I draw strands of coding that reflect these different patterns using the complexity theoretical framework developed in this thesis.

6.3.6 Opening Minds encourages student discussion and questioning

In describing previous categories related to the theme 'ideas about opening minds', I have noted that these ideas reflect in practice some of the ideas discussed in the theme 'teachers' beliefs about education', and this is also the case here. The notion that it is an important part of education to encourage students to question the world around them was identified in the discourses of teachers, and it became clear during the data collection that many teachers attributed an apparent change in attitude from the pupils to the discursive nature of the Opening Minds curriculum, leading to the informal label 'Opening Mouths' replacing Opening Minds from some teachers. Although it was argued by teachers that in reality, the students' attitude during the first year of Opening Minds was more attributable to the nature of the group than the influence of the curriculum, the ambivalence on the part of teachers to students' questioning of the teacher's authority and discussion of everything is an interesting finding. In particular, the Opening Minds teachers expressed both positive and negative ideas about this element of the students' responses during that first year of implementation of the new curriculum, commonly explaining that although it was problematic, in some ways this attitude on the part of the students also 'helped Opening Minds to work', thus linking the behaviour and attitudes of the students to the success of the more open-ended, process oriented curriculum discussed in the previous categories. Interestingly, although this theme is not so apparent in data from the students, where it does appear the students also express some ambivalence around the idea,

Student: In OM they say let your ideas out, that's why it's called Opening Minds, it's alright to say your idea, it's not like you have to put your hand up and stuff, there's not many restrictions – I think they should maybe change it a bit, maybe. (Field notes, 7/9/2010)

Unfortunately I was unable to follow up with this student what changes he thought they should make, as he had to return to his science lesson.

The suggestion that Opening Minds could be linked to an expectation of greater discussion on the part of the students, and more questioning of teachers, appeared throughout the data. Here, Declan describes how he saw the attitudes of school staff during the first year of OM,

Because I think there was a general kind of consensus amongst staff, it was almost a bit like Chinese whispers, that they're a very confident year group anyway, they're very mouthy and chatty, and is Opening Minds what they need? Because its giving them more confidence, they're having to verbalise things, they're having to do a lot of independent work in groups, and actually we're kind of boosting one of their particular traits which we think needs - careful channelling! (Declan)

This description summarises the general perception that came across in the data, and is interesting because it highlights that Opening Minds is designed to encourage student discussion and build their confidence and independence but also recognises that this aim might not be seen to be appropriate for all students as a general 'good' element of education. Declan is rather more careful in his language than other teachers discussing the same idea, and the language used by the teachers in discussing this topic is also interesting, as it very quickly shifts from a positive slant to a more negative one, for example in this quote from Declan, 'Other teachers said they're very confident, they're very articulate, they're very loud, they're too gobby. Opening Minds, Opening Mouths, I don't know if you heard that one?' Declan clearly sees advantages and at the same time recognises problems in the way Opening Minds is seen to (and in some ways aims to) encourage student discussion and questioning. This contrasts with direct reporting of concerns about this aspect of Opening Minds, for example in this from Jacob, 'their listening skills are diminished because all they are interested in is talking and expressing their own opinions'. Jacob's suggestion is that the discursive attitude encouraged by OM is not beneficial in science, because of the particular perception he has about what science education is for. Contrasting ideas about science and how it relates to the Opening Minds curriculum will be discussed further in section 6.5

Alongside evidence from interviews, there is also evidence of the teachers' need to find a balance between encouraging students to discuss and question ideas (including those of the teachers) with a need to maintain order and respect in the classroom. This came across particularly clearly in a lesson with Kate during the second year of OM, where the class had been getting a reputation amongst teachers for poor behaviour. She spent part of an OM lesson using the CLIPS competencies to focus on relating to authority and relating to adults, rather than emphasising discussion. As can be seen in the extract shown in Box 3, the pupils ask what to do if they want to question the teacher, and are told not to but to talk to the teacher (see highlights). The suggestion here is that there is a time and place for discussion

and questioning, and the students need to learn when this is not appropriate as well as when it is encouraged. This extract is a clear illustration of the tension between structure and freedom experienced by the teachers. The OM teachers, again particularly those with leadership roles within the OM team, express a belief that it is beneficial for students to encourage them to have a thoughtful, questioning approach to their learning, but this is balanced against a need to maintain teacher authority, work within the structures of the school, and manage the learning opportunities for all the students in the class.

I meet NS in the staff room before the lesson, glad to catch her there. She chats to me on the way across to the classroom, explaining that the lesson won't be as interactive as normal because with this class, they are very good at relating to the 'P' bit of the CLIPS (Relating to People) to themselves but not to her or other people in authority. This is based on her own lessons and also on feedback she has been getting from other teachers. As we arrive, I find a seat at the back of the room opposite two students, who look at me but don't speak. There is some kerfuffle over swopping seats, as none of them want to sit on a seat that has a penis drawn on it. I take that seat to leave the 'clean' ones for the students.

11.08 Kate puts hand up to get quiet: "Conversations from break time over now. 2 minutes to get your folders out of the cupboard and everything ready." The students get themselves sorted. Its an RE classroom, laid out in tables of 4. They get a 20 second warning and gradually counted down to be ready.

11.11 "Register time. No talking." Kate calls the register. Some students are still, others look through their folders but they are all quiet. Instruction from Kate to turn to the CLIPS in the back of their OM books. Learning Objectives are up on the board.

Kate: "With your shoulder partner, one of you read out P1, the other P2, P3, P4 etc. 30 seconds to pair share, to read out the CLIPS relating to people – off you go!" The students start reading. Kate hand claps in a rhythm which the class finish and then fall quiet.

Kate: "I'm getting concerned about what's going on in OM. You are working well in groups and teams. But have a look at P2. (Nick reads - P2 is 'You can successfully act as a group member or leader in any situation') and P3 ('You can co-operate with others'). I'm just a bit concerned that the behaviour of some of you means you're not able to cooperate with the teacher – you can with each other but not with the teacher – i.e. me! Not relating very well to the teacher, and other teachers have said the same thing." She sets the class off on a round table to discuss 'the behaviour I might need to do to cooperate with the teacher' (gives an example to listen when the teacher is talking.)

The class have 1 minute to say what positive behaviour they should be showing in the class. The class talk about it (on task so far as I can hear). Kate counts down and stops them talking, then reminds them of the code of conduct in the front of their OM books. She gives a 'talking stick' (a glittery wand-type object) to a student, which is passed around as the students give examples of their ideas. Kate writes all the ideas down on the board, occasionally praising suggestions.

- Don't talk when the teacher is talking
- Listen
- Contribute
- Know when to communicate (I've noted red herring against this in my written notes but can't recall why. I think Kate commented that this was rather a red herring as they were talking about how to communicate and not just when, but also praising the idea of know when is a good time to speak and when to listen)
- Not shout out
- Have fun
- Be happy
- Be helpful
- Not fiddle
- Put effort into work
- Know when to stop
- Look at teacher when talking (Kate says, yes, look at whoever is talking when they are talking, in reference to whole class discussion I think.)
- Don't answer back (Kate says as they go through these: 'answering back includes questioning – questioning why a teacher is doing something or what they are doing.')
- Don't get distracted
- Abide by the rules so that you can control the fun.
-

Kate: "You must know by now that my idea is that we are able to learn and have fun and be happy. And these things are to help that happen. Toby, I've mentioned your name already and if I have to do it again you'll have your name on the board." (Explains rules about names on board leading to detention. If they don't work hard to learn and have fun.)

[illegible]: Kid puts hand up and says "what if you have to answer back because the teacher says you've done something you haven't?"

Kate: "I wouldn't. You'll be digging a bigger hole for yourself. Talk to a teacher about it first."

Round table again, reading out code of conduct bullet points. They do this, as Kate puts LO's back up: To know about our own ancestors, and to understand animist ideas of ancestors.

Alongside the balance between encouraging students questioning and maintaining appropriate classroom behaviour, the relationship between OM pedagogy and the idea of encouraging student questioning is another important element woven in to this code. The relationship between the style of teaching in the Opening Minds curriculum and the attributes of students in terms of preparedness to question and discuss ideas was regularly raised by Opening Minds teachers in conversation with me, with the suggestion that the year group who were seen by some as problematic and a cause of the label 'Opening Mouths' also 'helped Opening Minds to work'.

There's the party line that [OM's] a great things because its giving the kids skills and that sort of thing and many people buy into that, so that's great. As I do. And then there's the undercurrent of last year it being called 'opening gobs' instead of opening minds, because we had last year a very cocky, arrogant year group. But that was just them. But people said it's because of opening minds that they're like that...So I say unfortunately, but fortunately in some ways because it helped OM work in some ways. (Isaac)

The balance between positive and negative perceptions of a questioning attitude from students is highlighted further when contrasted with the second year group to take Opening Minds, who were quieter and more placid and 'good' but more difficult to engage with the style of teaching in OM,

[The second year through] was harder work because you weren't getting the answers you were expecting, you weren't getting diversity and you weren't getting conversations because a lot of it's based around discussion isn't it? (Daniel)

The picture found in the data is more complicated than just the difficulties for the teachers in developing the notion of encouraging students' questioning balanced against the constraints of both the curriculum and the authority of teachers in OM and in the year 7 students' approach to learning in the wider school context. The perception that OM encourages students to be *too* questioning in the first year of OM was influenced by the characteristics and attributes of the students involved, and their interactions with each other and with their teachers. The influence of these interactions between teachers and students in relation to this idea of OM as encouraging questioning is a point that is further illustrated when these notions are contrasted with the perceived attitudes of students in later years of Opening Minds. This theme will be returned to and explored further in relation to the development of ideas about reflection and assessment in the trajectory of the OM

curriculum, as the teachers' responses to the perceived differences between the students and how this may interact with the subsequent changes made to the curriculum are explored.

The preceding discussion of this 'theme', 'opening minds is about thinking and questioning' has shown that there are multiple tensions in relation to the new curriculum in this area. The teachers experienced tensions between wanting to encourage students to question the learning, but not to question their authority. At the same time, the idea that questioning was perceived as both problematic but also helpful in relation to the 'different' OM pedagogy shows a slightly different slant to this tension. As with other aspects of the data presented in this chapter, these tensions are interesting to explore using complexity thinking and concepts of emergence and complexity reduction. The OM style of pedagogy advocated by the teachers, including a questioning attitude, can be seen as offering more potential for emergence through the educational relationships in the classroom, but this is in tension with expressions of teacher authority that manage this questioning along particular pathways in a form of complexity reduction that can be linked to mechanistic ways of thinking. Exploration of these tensions and the related interactions between students and teachers is part of the exploration of the complex trajectory of the OM curriculum, which cannot be summed up as a simple case of emergence *or* mechanistic change.

The idea that OM should encourage students' questioning was noted as a theme in the teachers' discourse but was drawn out through three interweaving elements; teachers' beliefs, the pedagogy of Opening Minds, and the interactions between students and teachers. The tensions within and interactions between each of these elements are important in this analysis. The suggestion that teachers need to balance a belief that teaching should encourage students' questioning with the structures of the school curriculum and hierarchy has already been discussed in section 6.2 and related to the difficulty in translating what could be seen as an open-ended and emergent, 'complexity thinking' approach with a more habitual and traditional mechanistic approach to education. This links to the way in which the discursive, more open pedagogy and curriculum of OM has been identified by teachers as being 'helped to succeed' by the students' questioning attitude, despite this attitude not being universally popular amongst teachers, particularly

teachers who are not involved in teaching OM. The idea that questioning is an important part of the OM curriculum was a critical part of the curriculum that changed over time due to the responses of the different students in the different year groups and their interaction with each other, the teachers, and the curriculum. Interaction between elements within a system is a crucial idea in complexity thinking, and is linked in the theoretical framework outlined in chapter 2 with both relational and temporal emergence. The nestedness of these interactions and their wider relationship to the emerging curriculum trajectory will be discussed later through the concepts of relational agency, power and reflexivity developed in chapter 3. This 'questioning' theme within the data exemplifies the interweaving aspects of teachers' beliefs, pedagogy, structural constraints, interactions between students and teachers and the curriculum trajectory.

6.3.7 Ideas about Opening Minds – summary

The ideas about Opening Minds expressed in this study reflect in many ways the different beliefs held by teachers about what education should entail. This is unsurprising and shows the existence of a relationship between teachers' beliefs and the curriculum that is planned and enacted. However, these relationships were not straightforward, as the enaction of the teachers' beliefs was mediated by their interactions with the emerging new curriculum, with each other and with the students. The ideas about Opening Minds expressed in the data show that the curriculum that emerged during the study entailed a balance between an open-ended, process oriented perception of the curriculum, aiming to encourage independence of thought and action on the part of the students, with the need to structure the learning, timetable, lessons, activities and classroom relationships. The curriculum was developed in response to a set of aims loosely focussed around the development of transferrable skills, but there was not necessarily agreement over what these skills should be. The curriculum was developed with the aim that it should be different, and focus on process and metacognition, but this focus was principally expressed by teachers taking the lead in the project and not strongly shown by all the teachers involved in teaching Opening Minds. The curriculum was strongly associated with particular types of products and activities, namely presentations and posters produced predominantly through group work, but teachers spoke of the necessity to balance valuing the product with valuing the process, and it appears that they experienced tensions in practice when it came to finding this

balance with the students. Breaking down barriers between subjects was a key aim in the initial ideas about the new curriculum, but this is balanced against a desire to maintain the differences and distinctions between subjects. Similarly, finding ways to break down these barriers was found to be problematic as students' appear to find it difficult to transfer OM ideas into other subject areas or into new topics within OM. And finally, there was a clear tension for Opening Minds teachers in relation to the aim of encouraging student discussion and questioning of ideas. Within each category from the data, then, teachers (and students) appear to be working to find a balance between an open-ended, different style of curriculum and an outcomes-led style with traditional expectations of behaviour and authority. This tension can also be seen in balancing the different curriculum aims and ideas found in the data. For example, the aim of developing particular skills and competencies that can be identified as lesson objectives could be seen as being in tension with the idea that Opening Minds is less constrained and students have more choice in the tools they use and are enabled to question and discuss ideas for themselves. I now turn to focus on 'reflection' as an important theme within the data that enables me to explore such tensions in greater depth.

6.4 Reflection and assessment in Opening Minds

An important part of the process of learning that was touched upon in discussion of the theme, 'Opening Minds is about thinking, process and metacognition' was the notion of reflection. This became a key idea that was adopted and discussed by all the OM teachers and not just those involved early on or those in leadership roles, and became an explicit part of the language of Opening Minds that began to spread around the school. 'Reflection' began to be used within OM as a form of assessment, replacing traditional styles of tests to assess particular knowledge or skills more common elsewhere in the curriculum. Teachers also referred regularly to their own use of and need for reflection in the development of the OM curriculum and their own practice. The conceptualisation of reflection by teachers and students further illustrates the balance between emergence, mechanistic change and complexity reduction throughout the period research was undertaken. The following section discusses different conceptualisations of reflection within the data.

6.4.1 Student reflection and the language of Opening Minds

Reflection, and the language and tools within OM related to reflection, rapidly became both the accepted OM practice and the main element that was communicated and made use of in other parts of Bridge Community School. Reflection therefore is a key part of the 'language of opening minds'. Two pieces of specific language associated with Opening Minds were linked to student reflection; the CLIPS competencies and 'What Went Well/Even Better If' (WWW/EBI). Both of these were discussed in the article about OM produced for the staff journal by Declan, the then leader of OM (see Box 4)

WWW: What Went Well

EBI: Even Better If

The 2 simple acronyms above have been integral to our teaching and learning in Opening Minds. They have been to a certain extent transferred to other curriculum areas. The students have become quite familiar with effective reflection on their progress.

Students have had most of their **OM** lessons taught in their tutor bases, by their tutors. There have been a couple of shared groups which have still been taught exclusively by members of the OM team.

■■■■ has been able to timetable the tutor groups simultaneously for a double lesson weekly this year and will hopefully be able to put us all on a double lesson together once a fortnight, '09-'10. This enables us to 'launch' new ideas / topics, celebrate success and reflect on WWW and EBI.

WWW

As a team, we have been able to start from scratch with our Schemes of Work. In pairs, we have endeavoured to create a fairly wide variety of tasks / challenges for the students. We tried wherever possible to follow the **PIES** principles of Cooperative learning, with **P**ositive Interdependence, **I**ndividual Accountability, **E**qual participation and **S**imultaneous interaction.

Students will typically start a lesson with Learning Objectives on the board and the relevant CLIPS criteria for that lesson also written up. Some tutors will ask the students to paraphrase the CLIPS for that session into their Learning Journals / verbally explain the purpose of the lesson, so that this is explicit, both in terms of lesson content and end products of lessons, as well as the processes that will be experienced by students.

Team building tasks / thought provoking images or questions / a challenge are often used to start a lesson. As the year has progressed we have been able, to a certain extent (they are 11 year olds!), to encourage the students to find ways of planning the different phases of a more complex task. They have had to decide who does what and how they will be able to succeed. Students have sometimes been willing to take on roles within small groups that they would not usually be comfortable accepting.

Box 4: Extract from staff journal article about OM, by Declan in 08-09

In this article, Declan used the WWW/EBI acronyms to structure both his personal analysis of the successes and areas to develop in OM, and to categorise some comments from

students and teachers about the project. There is also evidence of this simple reflective tool being used in the OM lessons observed, as demonstrated in the following,

The students start to bring their leaflets [on bullying] to show Daniel when they are complete. He asks WWW (what went well) and EBI (even better if) to the students when they talk to him before sending them back to their places. (Lesson observation, 21/11/09)

The WWW/EBI language of OM has also been used as a tool to move OM beyond the year 7 OM lessons into wider school use. Declan described an example where a teacher with a year 8 tutor group used this language to continue to build on Opening Minds during tutor time. Using such specific and particular language for reflection can appear rather simplistic, and Declan, whilst very clear that reflection is a fundamental part of OM, also spoke about finding a balance in the depth of reflection,

We're trying to make them do that [reflect] with everything they do, for a year. So sometimes it has to be superficial skim and sometimes it has to be really in-depth. (Declan)

Examples of 'superficial' or simple reflection using the WWW/EBI can be seen regularly in the students' learning journals, where they have been asked to write short sentences for each heading at the end of a lesson. Whilst examination of the students' learning journals and observation of lessons indicates that reflection is a regular feature of OM lessons, evidence that this reflection is in-depth as well as superficial is less clear. Declan gives an example of detailed reflection undertaken by one of the year 7 groups, where the teacher asked the students to re-work a piece of work three times to keep improving it: it is also apparent that it is rare to go this far, as he mentions that he himself would have been reluctant to do so.

He made them [reflect on and re-do] it for a third time and it was really powerful because of the Even Better If bit, and they were so proud of their end results...And it was the best of work any tutor group did last year and it was quite a powerful thing to make them redo it. And he just cut out another bit of content so he could do that. And they were so chuffed...I wouldn't have had the guts, I couldn't have have walked in again and said, 'hey kids, you know that work you did last lesson? Let's shred it and start again!' But that's what he did. (Declan)

The language of WWW/EBI adopted within the Opening Minds curriculum is interesting from a complexity perspective, because as a tool in itself it is potentially relatively open-ended in that the students have freedom over what they see as good or better, but the

predominant mode in which it is used in this case is as a structure for reflection on learning activities in a relatively 'closed' style. Even when the time allowed for the students' reflection and the depth of feedback offered by the teacher and other students varies, the general approach appears to be 'mechanistic' rather than 'emergent'. Whilst it is possible that, due to the open-ended nature of the questions 'what went well?' and 'even better if?', emergent ideas could be generated through a process of reflection using this language. Complexity thinking suggests that reflection could act more effectively as an 'enabling constraint' if the task on which the students are reflecting is rich enough to provide students with an opportunity to challenge their own ideas. However, if this language is used in the context of a relatively closed lesson activity in which there are clear outcomes or goals and clear success criteria, the WWW/EBI language is likely to be used in a more mechanistic fashion in which the reflection relates to the linear trajectory constraining the students' and teachers' activities. This makes the process of reflection more circular, developing students' knowledge along a predictable path which, although it can be argued that this has its place, is not the different, less constrained and questioning pedagogy which the OM teachers have discussed as being desirable (see section 6.2.4, 6.3.5 and 6.3.6).

As well as the WWW/EBI language, the CLIPS competencies formed a further set of language for OM which the students were regularly asked to use in their reflections. Teachers approached the use of CLIPS for reflection in two different ways. At times, the teachers used the CLIPS as learning objectives which they put on the board at the start of the lesson, and at the end of the lesson the students would be asked to reflect on where and how they had used them and if they felt they had learned about these competencies during the lesson. Where they are used as learning objectives, the CLIPS were generally combined with a more content-focussed objective as well (see examples in Box 5). This way of using lesson objectives is related to the common procedures in the school, where the teachers are expected to display an objective and be able to show at the end of the lesson that they (and the students) are aware of the progress the students have made against these objectives.

We have to put the learning objectives up at the start, definitely. The CLIPS have been - yeah, I suppose we've been told that we should have them up. I don't know, I think it would probably work better if it was a reflective tool in some instances probably.
(Matt)

This process ties in with the expectations of Ofsted for what is viewed as good practice, and is part of the school's teacher appraisal/performance review lesson observation form. Structurally, therefore, this use of the CLIPS as a tool to set objectives and review them at the end of the lesson is quite a powerful mechanism in the school and teachers feel that they are expected to follow this pattern. It is also a pattern that ties in to the concepts of assessment for learning that have been adopted by this school, and schools across the country, in which success criteria are shared with the students to enable them to self- and peer- assess their learning in relation to the objectives for the lesson or activity (Assessment Reform Group, 1999).

Extract from field notes: Declan, 29/3/10

9.05 Class arrive, books given out. Class are settling into the room. On board:

CLIPS:

C3: Others values

S1: Creating and developing a plan.

To create a realistic story about a sacred object, in the spiritual life of a village.

Extract from field notes: Daniel, 9/10/09

Learning Objective on the board, 'to be able to think in different ways'. CLIPS P1, P3 and S1.

Extract from field notes: Felicity, 17/11/09

The aim of this lesson is to review and reflect on the Food 4 Fun challenge. There is another visitor as well as me in the lesson today – Jessie explains to the visitor what they had to do. F also recaps what they had to do (in teams create a restaurant with healthy food).

LO's were: 'To understand the relationship between costs, prices, profits; enterprise skills' and 'work effectively as a team.' (P CLIPS)

Box 5: Examples of using CLIPS in lesson objectives during OM lessons.

The second style of using the language of the CLIPS in relation to reflection turns this around, and the CLIPS are used as a reflective tool without specifying in advance to the student which CLIPS they were supposed to develop in the lesson. This notion was developed and explained by numerous teachers during interviews, and I noticed on a number of occasions during lesson observations that the CLIPS were either only loosely

specified in lesson objectives, or these objectives were removed from the board after the beginning of the lesson and not used directly with the students for reflection until perhaps referred to at the very end, after the students had reflected using the CLIPS themselves.

Yes, yep. Well I'm very keen on them...what I don't like the idea of is me telling them what clips they're doing that lesson. Its them actually working it out for themselves. (Isaac)

One thing that I did find that worked well last year with OM was actually doing a task and not telling them what CLIPS they were looking at...I don't know if it is as valuable me saying we're doing this and we're doing this, as opposed to them looking back and going 'oh yeah, we did actually cover that, and we've covered that and we've covered that.' More of a reflective tool maybe. (Matt)

As well as Isaac and Matt, Daniel, Sam and William also expressed similar sentiments, indicating that they like the students to choose for themselves which CLIPS they felt they had been using in a lesson, as part of a reflective process.

The CLIPS competencies as a language with which to promote students' reflection is rather different from the WWW/EBI language discussed previously. With the WWW/EBI, the questions asked are relatively open-ended but the way they are used in relation to the curriculum activities tends to be mechanistic and rather than emergent in style, whereas the CLIPS are simply a list of 'competencies' – skills – that are used a structure to direct the reflection. The use of particular language has been linked to complexity reduction (Biesta, 2010a), and some of the ways in which the CLIPS competencies are used in reflection can be considered in such a light. However, the OM teachers linked CLIPS to reflection in two contrasting ways. The first of these used them as learning objectives, asking the pupils to reflect on how they had used these CLIPS during the lesson at the end: this can be viewed as a form of assessment for learning and is discussed in more depth below. The second style of using the CLIPS to reflect is potentially more open, where the students are not prompted about which CLIPS they will be using, but left to reflect at the end of a lesson or activity on their learning using the CLIPS as a general prompt. This latter style could be seen as using the CLIPS structure as an *enabling* constraint, with student choice and discussion during reflection creating a more emergent style or pedagogy in relation to reflection. On the other hand, as with the WWW/EBI language, despite the potentially more open-ended and emergent nature of reflection using CLIPS as a structure rather than an objective, the

examples in the data suggest that the way this has worked in this case leans towards the mechanistic rather than the emergent. As with previous themes in the data, this perhaps suggests that teachers' use of reflection leans towards a more habitual, linear and mechanistic way of working rather than a more emergent style which might tie more closely with their relating reflection to the new and the different in the curriculum.

A final element related to student reflection in OM relates to the students' own attitudes towards the reflection they are being asked to do, and the extent to which they engage with it. Teachers' comments suggest that the students do not always enjoy engaging in reflection on their learning, as illustrated in the following comment from Declan:

I think the whole, the big difference is that you reflect on it and again, that's really hard because you've got to think of different ways of getting kids to reflect. Because what they don't want to do is get a funky exciting idea, there's the buzz of excitement when you decide what to do and then there's the argy bargy of who'll do what, then there's sir or miss telling us we have to be going in this direction or that direction, then we present it, then we're pleased with it or a bit disappointed and we get marked on it and then we go, 'oh no, we've got to do the reflection sheet aargh, we've got to write down how did it go... I want to go on to something funky and new and exciting, I don't want to talk about what we've just done. (Declan)

Declan notes the students' negative responses to being asked to reflect both in lessons and in the school's initial evaluations of opening minds and explains the need to address the students' reluctance to engage in reflection by finding different and innovative ways to encourage it. This is an interesting contrast to the idea that it is beneficial for students and teachers to have a common language to use to support reflection through the CLIPS and the WWW/EBI approaches already discussed, and is another element of tension for the teachers in creating a new approach to curriculum. The issue of students' engagement with reflecting on their learning using the language of CLIPS was also mentioned by Daniel, who raised concerns that the students see reflection through the CLIPS as repetitive rather than moving forwards.

"My big worry is that we've got 25 CLIPS or 20 CLIPS, I don't even know how many there are, and there's all these statement and if you are to run it all the way through from Year 7 to year 11 and you've got a teacher stood up at the end and say, 'what CLIP have we done' and some kids just gets their planner out (puts on a bored voice), 'we've managed the situation, Sir, yeah, we did it in Year 7 and we managed a situation in year 8 and 9 and 10. Yeah, I'm managing a situation at home as well, aren't I a great citizen?' The repetitiveness of just keep going over these same things,

I don't know if kids would see the value in that. That's just like when you are faced with something every single day you switch off to it don't you?" Daniel, OM teacher.

An important point raised by Daniel here is that the students need to see the value in repeating their examination of the CLIPS competencies in various contexts as they go through OM and beyond, which raises a concern that they could see reflection on their learning using the CLIPS as a structure as repetition rather than affording them an opportunity to move into new territory. The question of whether reflection is a repetitive strategy contributing to a mechanistic, stepwise trajectory or acts towards emergent trajectories will be explored shortly in relation to the range of approaches to reflection apparent in this case using a complexity thinking approach and the temporal-relational concept of reflexivity developed in chapter 3.

In discussing previous themes, I have shown that some OM teachers believe that reflection is an important part of education and a key element to Opening Minds. However, the reactions of the students to this part of the curriculum also has a part to play, in the interactions between teachers and students and their influence on the curriculum trajectory along the lines highlighted previously in section 6.3.6. In chapter 3, I discussed the way complexity enables a different perspective on the structure/agency debate, and in this case the agency of the students in choosing the extent to which they want to engage in reflective activity with the teachers, with each other, and with the curriculum or move on to something new is perhaps in tension with the curriculum structures that have been developed for Opening Minds. Considering reflexivity an important element in the interwoven relationship between structure and agency, in chapter 2 I discussed three ways in which reflexivity can be explored, employing the three different strands of the theoretical framework; relational emergence relating to the concept of enabling constraints, complexity-reduced goal oriented reflection, and a 'temporally emergent' conceptualisation of reflexivity in which past, present and context are reflected on in order to invent something radically new. The style of reflection discussed in this section appears to be most closely related to the first two of these, with interactions between student, teacher and curriculum that also act to constrain reflection towards a mechanistic approach.

6.4.2 Developing reflection as a form of assessment in OM

During the first year of Opening Minds, it seems that the teachers were mainly focussed on writing and planning the new curriculum, and did not spend time assessing the pupils' in relation to the OM competencies. They also recognised that they had not developed ways of assessing the pupils in Opening Minds, and part way through the year they introduced the use of CLIPS as lesson objectives in an attempt to begin to address this,

Assessment is another thing we need to get sorted...the difficult thing is, you want to assess them on [the competencies] and not on how pretty was my project, so that's tricky. Staff have trialled lots of different things because actually you do have to value the content...So it's quite a balancing act, but what you want to get out of it is do they think they've achieved P1 – in making the model, have they related to the group well? So it's a tricky one and on our learning objectives – this is something we've just trialled this term – when the teacher writes up the learning objective for the lesson they also write up: P1, L4, so every lesson has got a competency as an objective and every half term they look and they assess either in pairs or on their table or by themselves: 'Oh, which of these do I think I've done?' (Winnie)

Winnie's description of their move towards the use of CLIPS as learning objectives and reflection on the CLIPS as a review process and form of assessment neatly ties together some pre-existing school systems (assessment by teachers and students against learning objectives and success criteria) with one of the aims of Opening Minds (reflection and a focus on processes in learning) to develop a system of assessment that could perhaps be labelled 'reflection for learning' rather than the usual 'assessment for learning'.

The use of reflection using the CLIPS in a more formalised way at the end of every half term was continued into the second year of OM, where teachers spoke of a desire to develop and improve some way of assessing the students. Both William and Isaac made use of CLIPS review sheets in lessons I observed. The way these teachers used the CLIPS as a reflection and assessment tool was to provide a sheet with a list of all the CLIPS. The students were then expected to look through their learning journals and put examples of where they had used each of the CLIPS during their work in Opening Minds. This therefore appears to be a relatively 'superficial skim', rather than in depth reflection, but it does allow the pupils to say which CLIPS they feel they are more confident in, or have used more in OM, rather than the teacher telling the pupils which ones they have done which is more in keeping with the teacher's preferences discussed in the previous section.

Alongside a formal use of the CLIPS review sheets as an assessment tool, students were regularly asked to reflect using the CLIPS at the end of lessons, and the notes thus produced in the learning journals were used by the teachers to begin to attempt to assess the pupils in relation to these competencies. However, as my field notes show, I am uncertain whether the students' use of the CLIPS in the learning journals was a helpful form of assessment, and indeed was unclear until later conversations with the teachers whether the notes the students were making in the journals was a form of assessment,

Looking at a few of their learning journals, it seems to me that they are more confident and analytical when they are speaking about the CLIPS than when they are writing them down. Just an impression but I wonder if it follows a pattern and how much it matters what or how much they write down (e.g. for assessment?) Also, when talking as a class they are being scaffolded by the teacher...(Memo in field notes during an OM lesson, 16/10/09)

As well as reflection on the CLIPS being used within Opening Minds lessons as a technique for the teacher and the students to 'assess' their learning or progress in relation to these aims, some evidence suggested the use of student reflection on their learning extended to other classes taught by OM teachers. For example, William commented on his use of reflection with a year 8 maths class,

I've just had my Year 8 group and we spend the first part of the lesson assessing our books as to - I got the kids to look at the objectives we covered (we've got a test on Monday) and ask, 'how good are your notes, how good are your comments, your reflections on your work, and how good are my comments?' So they had to then come up with areas they felt they needed to develop to work on before the test on Monday so that on Friday they can come to me and say, 'I need to work on this, this and this' and I've got the resources prepared for them. So I feel the kids are better able to assess where they are and sit down and observe their learning and assess their progress and I felt I was speaking the same language, they were speaking the same language as me whereas with other classes I've tried that with they've found it more difficult to go through that process, so the assessment process they went through in OM was really helpful. (William)

William's comment here is very explicit in talking about an 'assessment process' in Opening Minds that involved reflection and self-assessment of the students' learning; further indication that this process of reflection was an important assessment tool as well as a key aim for OM. The relationship between self-assessment and reflection, with the implication that the emphasis on reflection within OM enabled the students to become more effective at self-assessing their learning in other subject areas and in later years, is an interesting link

made by William. The questionnaire data suggests that to some extent, students who were studying/had studied Opening Minds were more likely to respond that self- and peer-assessment helped them to learn, although neither tool was ringingly endorsed by the students in this data (see Figure 11 and Figure 12). No significant difference was reported in the data in relation to students' opinions of teacher assessment helping them to learn.

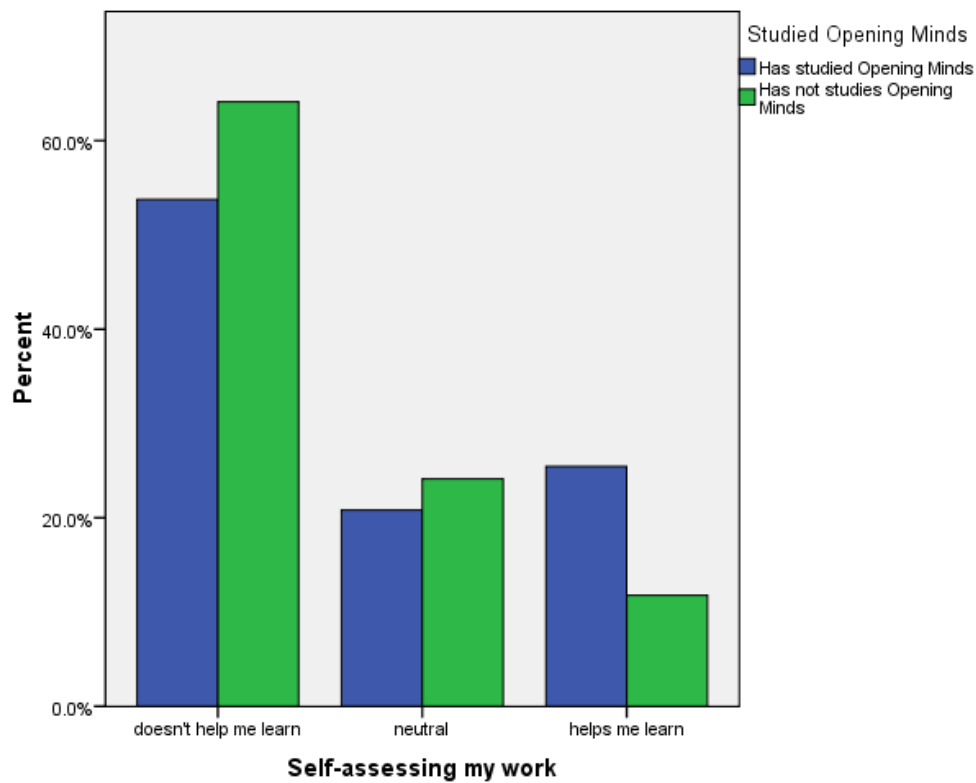


Figure 11: Self-assessing my work. More students who had studied Opening Minds felt self-assessment helped them learn than students who had not, but for both sets of students, the majority did not feel self-assessment helped them. ($\chi^2=12.886$, $p=0.002$)

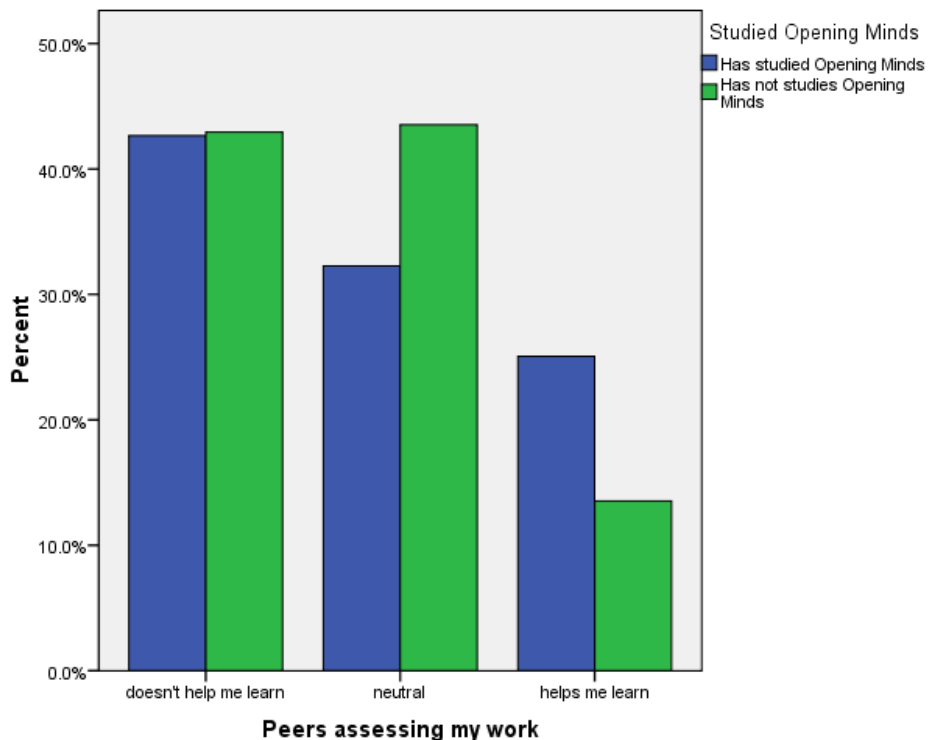


Figure 12: Peer assessment. A similar percentage of students who had and had not studied OM felt that peer assessment did not help them learn, but more students who had studied OM felt that peer assessment helped them, and fewer expressed no opinion than in the group who had not studied OM. ($\chi^2=11.163$, $p=0.004$)

The implicit relationship between peer/self assessment and ‘reflection’ within the opening minds curriculum links the development of assessment ideas in OM with assessment for learning ideas that were already part of the school’s way of working prior to the introduction of Opening Minds. The questionnaires show that OM had a small but significant impact on the pupils’ perceptions of self and peer assessment, but the data does not give any insight into whether and how the pupils related the ideas about reflection they experienced with the OM curriculum (whether open-ended or mechanistic) with their idea of what peer and self-assessment mean. In this case, the pupils were more likely to report that teacher assessment helped them to learn than either peer or self-assessment, suggesting that reflection as a form of assessment was not seen by the students as useful in supporting their learning. It is easy to speculate that this is because students associate assessment with understanding particular knowledge and skills (a mechanistic goal), and this is something it would be interesting to explore further, along with exploration of students’ perceptions of the relationship between reflection, assessment, and whether learning is seen by students as mechanistic or emergent in different contexts.

6.4.3 Summary of reflection in Opening Minds

The findings presented in this section show that reflection was seen by the OM teachers as a crucial part of the OM curriculum, in relation to what made it distinctive and different: more open and more process-oriented than the content-driven, subject-based and traditionally structured curriculum found elsewhere in the school. Traditional systems of assessment in the form of end-of-topic tests were not easily translated into this emergent curriculum environment. At the same time, reflection in OM was structured around particular language and had a tendency towards more mechanistic approaches that were in tension with the open-ended ideals expressed by the teachers. As the curriculum developed, the 'language of opening minds' supporting reflection became associated with assessment within the new curriculum, which was linked with notions of assessment for learning that were already prevalent in the educational discourse both within the school and nationally. In chapter 7, the ideas about reflection are considered in relation to other aspects of the data and are explored from a complexity thinking lens. In particular, four conceptualisations of reflection are considered in relation to theoretical ideas discussed in chapters 2 and 3. These are reflection-as-process, reflection-as-interaction, reflection-as-assessment, and reflection-as-action. Each of these elements will be discussed using a complexity-informed perspective contrasting emergent and mechanistic ways of thinking about reflection in education.

6.4 Relationship between science and OM

During the study, I chose to focus on one 'subject area' to examine the relationship between the new Opening Minds element of the curriculum and a more traditional curriculum area. I chose to examine science because of my own background as a science teacher and my pre-existing relationship with the department, meaning that access was relatively simple to gain. Also, science was one of the subject areas which had 'donated' time to Opening Minds, and so I anticipated that there would be some interaction between the two areas.

Previous descriptions of the data collected during the project has already indicated some sources of tension between the beliefs held by science teachers and OM teachers about the aims of the new curriculum, and what should be included in education. During data collection, it quickly became apparent that some members of the science team were some of the more vocal members of staff in criticising the Opening Minds curriculum, with one science teacher apparently responsible for the Opening Mouths label given to the new

curriculum in its first year. However, this criticism was not universal and it would be a mistake to portray the two curriculum areas as being in conflict throughout. Despite this, there are clear areas where the perceptions of the science team about Opening Minds, and the Opening Minds team about science, were not always in synergy. Of particular interest is the perception amongst many of the Opening Minds teachers that that language and tools of science are abstract and prescriptive, making it difficult to incorporate science into the more discursive and reflective nature of Opening Minds. In some ways, this view was also reflected in conversations with the science teachers, which is perhaps surprising given the nature of the discipline of science (in contrast with school science), a point I shall return to in my later discussion. In this section, I begin to explore the data in this case relating to the interaction between science and Opening Minds.

6.4.1 Science at Bridge Community School

In chapter 5, I briefly provided some descriptive background about the science department and the teachers who participated directly in this project. As with other subject areas, the department has been involved with various changes to the curriculum during the period of the research. In 2006, new GCSEs were begun with a greater emphasis on 'How Science Works' and science processes rather than content, which was reflected in the change to the curriculum at KS3 in 2008. In 2009, the National Curriculum Tests (SATs) were scrapped, and eventually replaced (albeit on a non-statutory basis) with 'Assessing Pupil Progress', a system of teacher assessment. During this period, the science department was encouraged by the Headteacher to move towards completing KS3 in two years in order to begin teaching GCSE modules to pupils in year 9. The departmental backdrop against which Opening Minds was introduced, with the loss of a year 7 science lesson per fortnight to Opening Minds, was therefore one of change which left the teachers feeling pressured for time to prepare the pupils to begin their studies in science at KS4.

During the period of the research, two complete science lessons were observed, one with year 8 and one with year 9. Other observations of science lessons took place informally but were not recorded for the purposes of the research. The science lessons tended to follow the usual structure common in the rest of the school, with learning objectives written up at the beginning of the lesson and activities undertaken with the pupils working individually, in pairs or in small groups in order to meet these objectives. In science, such activities

commonly involved or referred to some element of practical work. The two science lessons observed for this study had rather different activities, but interestingly both involved student's explaining their understanding to others, and both involved the teacher responding to unanticipated ideas and behaviours from the pupils. The year 8 lesson involved the use of Cognitive Acceleration in Science (CASE) materials, which were also used in Opening Minds. I was unable to observe any science-related lessons being taught in Opening Minds during the period of data collection. Both of the science lessons observed included elements that could be interpreted as both mechanistic and emergent, blending more traditional approaches to science teaching with ways of working that could be described as unpredictable. In the year 9 lesson, students were using their understanding of enzymes to explain a practical activity they had completed in an earlier lesson and were expected to meet the lesson objectives discussed at the start of the lesson and use the lesson to prepare for an assessed homework task they would be set later that week. In this sense, the lesson followed the typical lines of what would be seen as a 'good' lesson in relation to the standards set by Ofsted. Students were able to demonstrate good subject knowledge and the progress they had made during the lesson, were able to relate their work to clear success criteria that had been shared with them, and knew what they needed to do to improve their work in the upcoming tasks. All of these elements can be viewed from a complexity perspective as mechanistic. Alongside these mechanistic elements, and threaded within them, are elements that tie more closely with an emergent perspective. This was seen in the teacher's response to the students who were talking, off-task, about the upcoming release of a new 'Twilight Saga' film. Rather than simply closing this discussion down, the teacher linked the students' topic of conversation back to the topic of the lesson, asking students to think about enzymes in relation to a vampire's diet. This provoked a few minutes of class discussion which really engaged the students in exploring the lesson content in a different way whilst at the same time providing the teacher with a different perspective on the students' understanding of enzymes. The interaction within science lessons between emergent and mechanistic approaches is similar to that noted in the data in relation to Opening Minds, discussed in previous sections of this chapter, and is a theme that will be taken up in discussion of the science teachers' perceptions of OM and the OM teachers' perceptions of science.

6.4.2 Science teacher's perceptions of Opening Minds

The teacher's perceptions of the changes to the new curriculum were gauged through a teacher questionnaire and through interviews. Eight science teachers completed the teacher questionnaire, four male and four female, with years of teaching experience ranging from one to thirty. Only one of these teachers had been involved in developing Opening Minds, with a further two reporting that they had had some training in the OM initiative. A summary of the questionnaire results for these teachers can be found in Table 9.

Table 9: Mean values of science teacher's responses to Teacher Questionnaire. Teachers were asked to respond to each statement using a scale of 1-5, where 1 indicated 'strong disagreement' and 5 indicated 'strong agreement'.

Statement	Average response from Science teachers with no experience of OM	Average response from Science teachers with experience of OM in some form	Average response from all Science teachers
I am aware that students work towards the CLIPS competencies	4	3.66	3.875
I am not familiar with the individual CLIPS competencies	3.6	2.67	3.25
OM has had a positive effect on Year 7 students' learning	2.6	2.33	2.5
OM has had a positive effect on Year 8 students' learning	2.4	2.33	2.375
There is no difference in my students' learning if they have done OM	2.6	3.67	3
OM has made a difference to the way I teach my subject	2.2	2.67	2.375
I do not refer to OM in my subject teaching	3.8	3	3.5
OM ideas are important for students	3.6	3.67	3.625
I don't think students enjoy OM	3.25	4	3.57
OM is fun for the students	3	2.67	2.86
I think parents have a positive attitude to OM	3	2.33	2.71
I am worried that OM is taking time away from learning subjects	3.6	4	3.75
It doesn't matter to me that subjects lose curriculum time to OM	2.2	1.33	1.875
OM takes up too much time	3.8	3.67	3.75
Finding out more about OM is a priority for me	2.2	3.67	2.75

Since the sample was limited in size, these results are used for descriptive purposes only and not deemed sufficient for statistical comparison. The results indicate that the differences in response to OM between science teachers who had been involved or trained in OM and those who had not were not large. The results suggest that while the teachers were aware that students in OM worked towards the CLIPS competencies, they were not very familiar with the individual competencies. The science department did not feel that OM had a positive impact on students' learning in year 7 or 8, nor had it made a difference to the way science teachers taught their subject (though the teacher who had *taught* OM indicated that it had made a difference). Science teachers felt that the ideas in OM were important for the students, but didn't think that students enjoyed OM. They were concerned that OM took time away from subject teaching and felt that OM took too much time. The mean responses of the science teachers were fairly neutral about whether parents had a positive attitude to OM, edging towards disagreement with this statement. They were also just to the 'disagree' side of neutral in their response to whether finding out more about OM was a priority. The summary results from the questionnaire therefore indicate that the science teachers held a relatively negative perception of Opening Minds, despite agreeing that the ideas in OM were important for students. This data ties closely with the results from interviews described in earlier sections, where it appeared that science teachers felt that learning skills was important for students, but were unhappy with the way OM had developed and the emphasis and direction the OM curriculum had finally taken.

The science teachers spoke of a concern that Opening Minds was not 'delivering' what they had hoped for. In particular, Louise, the Head of Science, was concerned that they had given a lesson to OM but that the science skills they had hoped would be included in OM had 'fallen by the wayside'. Louise, Matt and Toby all described the way that the lesson 'donated' from science to OM had originally been used by the science department to teach Cognitive Acceleration through Science Education (CASE) lessons. This programme, originally designed and developed by science educators in the 1980s, was adopted by many schools and has continued to be developed and used since its inception, either as separate 'CASE' lessons or as tools to weave in to a school's science curriculum (Adey, 1999). The Cognitive Acceleration programmes are designed to develop students' thinking skills, with a 'focus on questioning, collaborative work, problem-solving, independent learning and challenge' (Let's

Think Cognitive Acceleration, 2009). The CASE materials develop these areas using ideas about scientific thinking, such as using control and manipulation of variables to solve problems. As Matt suggests, the stated aims of CASE and Opening Minds are similar, and so one might anticipate that the incorporation of the CASE lessons in to the OM curriculum would tie together well,

Because like I said at the beginning, I'm a scientist but I think with the actual aims of the project with looking at all the CLIPS things, to actually – I think Science holds a lot of those, like I said, holds a lot of them together. So it, it seemed that the two kind of went hand in hand. (Matt)

However, when the science teachers spoke about CASE as an element of Opening Minds, they were disappointed with what had happened in the OM curriculum, feeling that the science element had got lost.

...We feel from a science point of view because we gave up one of our science lessons that we use for CASE...which actually although not every [science] teacher enjoyed it was actually quite useful thing to do and we gave up that lesson on the premise that they would include CASE ideas in every lesson in OM but what actually happened was they had one lesson tagged on to the end of the module where someone did some CASE with them. Well, after losing one lesson a fortnight for them to include that we felt a little bit hard done by the fact that that has just been used to get more RE, Geography and History into their curriculum...(Toby)

Toby's insight that science teachers did not always enjoy teaching the CASE lessons is interesting, in light of the general feeling of disappointment with the way it was managed within Opening Minds. Matt echoes this sentiment, whilst explaining in more detail his perception of the problems associated with CASE being incorporated into Opening Minds,

[sighs]. This is the argument that we had because we gave up a lesson to OM from science, which is where we were doing our CASE lessons. And CASE was supposed to be delivered through OM, which did seem quite a good idea because you're looking at cognitive abilities and linking those to scientific – but I think it was quite unsuccessful...The ones, the lessons...when we had [a teaching assistant who is] very experienced on [CASE] and she knows exactly what the language is trying to hit and she knows exactly what the aim of the task is and how to run it, and on lessons where she was free she was going in and team teaching with the OM teachers of CASE. And that was incredibly successful. Actually that was very successful compared to when it was in-house in science. Because I'd not taught CASE before so being a new teacher I found her insight incredibly useful. So I understand what it would be like to teach CASE if you, if you weren't familiar with the context. Because it isn't like trying to get knowledge across, it's about trying to get the kids to develop their own ideas. (Matt)

As Matt notes here, having a teacher who has been trained in teaching CASE helps to increase the success of the lessons. This point was echoed by the OM teachers, and will be discussed in the next section. However, despite Matt's acknowledgement that the CASE lessons with the CASE expert were successful compared with the previous CASE lessons taught within science, the main perception is that CASE was not successfully taught within OM by the non-specialist teachers, and one expert to team-teach was not sufficient to overcome this problem. Matt identified the lack of specialist knowledge amongst the Opening Minds teachers as a potential cause of the difficulty, a point I will return to from the OM teacher perspective later.

You know, CASE was unsuccessfully delivered. Partly on the point that non-scientists were delivering scientific lessons which actually conceptually were quite difficult...the language is very specific, so if you're a non-scientist and you're talking about dependent and independent variables or you're trying to identify differences of pitch in different lengths of tubing, there – there are lots of misconceptions in there and I think if you're not completely happy with what you're doing I don't think – I think on the whole it was quite unsuccessfully delivered, CASE. (Matt)

In comparison with Matt's suggestion that teaching CASE is more difficult for non-scientists because of the specialist knowledge and language required, Toby felt that this ought not to be a problem,

But these are basic skills that everybody should have when they are learning and when they are teaching so I think as teachers we should be adaptable enough that we can cope with those basic skills. So at the end of the day we've got our subject knowledge to teach but actually our job is to teach so it's knowing how to deliver the information and pass that across that we need to be able to do. (Toby)

From the science teachers, then, we have a perception that the science skills developed through the CASE lessons are desirable, though perhaps not enjoyable to teach for either scientists or non-scientists without training. However, the teachers also felt that CASE was not effectively taught within the Opening Minds curriculum. This led to some resentment amongst the department over the loss of a science lesson to OM, since the science aspect of OM was not effectively taught in the first year through and then rather 'lost' in the second year of OM, with Toby suggesting that OM was used by the OM teachers to put more humanities into the curriculum at the expense of science.

The lack of a science teacher within the OM team during its second year was seen as a contributing factor in the perceived lack of science in the OM curriculum. Combined with the other curriculum changes occurring at the time, the science teachers didn't feel that the CASE skills lessons could be brought back in to science, so it seems that they got left out altogether due to a lack of curriculum time,

I know Daniel's worked really hard and has put up a big display in the staff room to see where [OM] would fit with the curriculum, but again, we have such a tight curriculum in science that we've got to deliver, and APPs and losing a lesson, that actually there isn't any room for manoeuvre. We haven't even got time for a field trip. And then I look at the trips that they are doing for Opening Minds and I think, 'Oh, that would be lovely if we could do that' but we haven't got a scientist in the team...so it gets dominated by the people whose subject it is. (Louise)

We haven't got the time [to bring CASE back in to science]. So literally that lesson was given away and with the new schemes and the new assessment without SATs we really don't have the time. If it has gone from OM then I would almost certainly think there's almost no science being taught in OM at all now. Other than a little bit of sustainability and a bit on diet, there, science will be pretty much void in the whole programme. (Matt)

Both the questionnaire and interview data from the science teachers indicate a certain dissatisfaction with the new OM curriculum. Although the CASE materials appeared to fit relatively well with the articulated aims of OM, science teachers were concerned that these were not taught effectively and eventually lost from the OM curriculum, which led to some resentment at the loss of a science lesson each fortnight to OM, particularly when combined with a pressure of time in science due to other simultaneous curriculum changes. Perhaps if the teachers felt that OM was effectively helping students to develop in terms of their learning skills, losing a lesson and the CASE element of the curriculum might be overlooked, but the science teachers were also the teachers who most commonly described a wish to see students learning specific skills in OM, such as evaluation and graph-drawing and they did not feel that these skills were being developed,

By the end of the year, I felt very disillusioned with [OM] in terms of anything being delivered. I was actually teaching year 7 alongside and I didn't see the spin-offs in my science lessons. I didn't see the skills whereby, you know, I wanted line graphs and bar charts...and it wasn't there...I didn't see the positives I don't think. (Louise)

Despite this, some science teachers did feel that OM was having an impact on the students in terms of their confidence and willingness to engage in science lessons as a class, stating

that they are more prepared to 'have a go', possibly because they know each other so well having worked together a great deal in OM (Field notes, informal discussion with Patty, a science teacher teaching Isaac's year 7 group).

Results of the teacher questionnaire indicated that in a few areas, there were significant differences between the perceptions of Opening Minds teachers and the perceptions of the science teachers, but not in all areas. Unsurprisingly, Opening Minds teachers were significantly more likely than science teachers to agree with the statements that Opening Minds had a positive impact on year 7 students (OM Median = 4, Science Median = 2.5, $U=14.000$, $r=-0.58$, $p<0.05$) and on year 8 students (OM Median = 4, Science Median = 2, $U=10.000$, $r=-0.667$, $p<0.01$). Science teachers were significantly more likely than OM teachers to be concerned that OM is taking time away from subjects (Science median = 4, OM median = 2, $U=15.000$, $r=-0.56$, $p<0.05$) and takes up too much curriculum time (Science median = 4, OM median = 2, $U=17.000$, $r=-0.53$, $p<0.05$), which supports the perceptions of science teachers drawn from the interview data discussed. Finally, OM teachers were significantly more likely to report that OM is fun for students than the science teachers (OM median = 4, Science median = 3, $U=13.000$, $r=-0.58$, $p<0.05$). Although this difference was significant, this was one area where the mean response from the science teachers was closer to neutral (mean = 2.86) compared with a positive response from OM teachers, unlike the other categories where science teachers tended to respond negatively compared to OM teachers' positive responses. In informal discussions and interviews, science teachers either suggested that they didn't know enough about OM to be able to say if it was fun for students, or that they thought students found OM rather repetitive, with too much poster and presentation work and insufficient challenge for the most able. This analysis suggests that there are some significant differences in response to OM amongst science teachers and OM teachers: While not surprising in itself, this provides further evidence supporting the interview findings in the previous section about science teachers' perceptions.

As identified earlier in this analysis in the context of Opening Minds, the science teachers' responses to OM weave together with their ideas about teaching and learning in ways that can be seen as both emergent and mechanistic. For example, Matt's comments show tensions for him in his ideas about science relating to ideas of experimentation and questioning, but at the same time he is concerned that non-scientists might not be able to

appropriately teach difficult concepts in science correctly. In discussing these tensions in the next chapter, I explore how complexity thinking approaches might support teachers in managing these sorts of tensions in the context of approaches such as CASE, or Inquiry Based Science Education (IBSE).

The findings outlined above show that for many of the science teachers, their perceptions of Opening Minds were influenced by their pre-existing ideas about what constituted 'good' science education and the way it made use of the CASE materials that had previously been included in their subject-specific curriculum. As discussed earlier, the teachers' values and beliefs about what is important in education influences their approaches to the curriculum, and in this case, the science teachers often felt that specific skills and ways of thinking scientifically were important for students to develop in contrast to the more general skills eventually included in Opening Minds. This is an interesting point to explore in relation to the wider literature about science education and the nature of science, as school science does not always reflect ideas about the nature of science held within the wider disciplines of science and philosophy of science (Donnelly, 2001). The interaction between disciplinary ideas about the nature of science, how these are reflected in the school curriculum in the ideas of science teachers and students' perceptions of science, and how these ideas relate to the 'cross-curricular' Opening Minds activities are interesting to explore from the perspective of complexity thinking. The science departmental perspective on Opening Minds can be seen as being influenced in multiple ways by the science teachers' ideas and beliefs in relation to their subject, the science curriculum, the Opening Minds curriculum, and the perceptions of the OM teachers, which I explore in the following section.

6.4.3 OM teachers perceptions of science in relation to OM

When I asked OM teachers about other subject teachers' perceptions of OM, science was the one subject area specifically and freely mentioned as having some teachers with relatively negative ideas about Opening Minds, which in some cases was a source of frustration for the OM teacher.

My feeling is I think it's probably just one or two individuals: it's a very big department but I think the Science department...I've heard more concerns voiced from there than anywhere else perhaps. (Declan)

However, OM teachers recognised that the science element of the OM curriculum had not been so successful, and gave a number of reasons why that might have been the case. These reasons varied from logistical difficulties, the style of the science aspect of the curriculum, lack of training and a perception of science that perhaps did not marry well with the aims of Opening Minds or with the rationale behind the CASE approach to science.

It was recognised by the OM teachers that the CASE lessons 'dropped in' to the curriculum as separate lessons 'lifted straight from science' were problematic.

The first year we ran it we had a senior science technician who came in and ran it and launched it, and I think it was probably the area of OM we were least happy with. Because we didn't have enough apparatus, we weren't really - it was things like fulcrums and balances and forces and mass and marbles. And it could have been really fun but it was kind of just lifted straight from science...(Declan)

There were lots of these little thinking through experiments that we did. Well it was CASE lessons. That's what we were doing and they were dropped in...(Isaac)

This apparent maintenance of a separation between the science lessons and the rest of the Opening Minds topics may result from the request by the science department that the CASE lessons (which are a specific style closely linked to the science curriculum) be the part of science that is included in Opening Minds. It may also suggest a lack of comfort with the science subject material in comparison with the rest, leading to a lack of integration in the curriculum that was developed. Daniel, reflecting on the relationship between science and Opening Minds, suggested that although the aims of OM and CASE could be seen as related, the CASE materials appeared to the OM teachers to be prescriptive and dry, and commented on the need to integrate it more with the style and pedagogy of Opening Minds – to 'OM it'.

CASE on the face of it looks very dry and we needed to OM it – we needed to make it Opening Minds. It already was but there was just like - you know, on the face of it you saw worksheet, worksheet, worksheet, read the worksheet, let's do this. (Daniel)

The contrast between this perception of CASE as a worksheet-based pedagogy and the idea of CASE (as expressed by Declan, below) as being about trying out experiments and thinking about ideas, is particularly interesting, reflecting the contrast between a prescribed, ends-based curriculum and an open-ended curriculum which encourages students' own questioning and experimentation. This suggests that the tensions between closed and open,

mechanistic and emergent, are reflected in the teachers' interpretations of the science materials they were asked to teach. The relationship between the teachers' ideas (and identities) and the OM-science curriculum is an area in which relational agency can be seen to be enacted as the teachers' interpretations of science, in relation to their ideas about their own teaching and their students' needs all influence what is done with the materials whilst at the same time, the CASE materials themselves can be seen to influence the way the different teachers approach the 'science bit' as closed or open-ended.

It was meant to be smart science, so its accelerated. They don't have to record much and they just try little experiments, see how it goes, talk about it...(Declan)

It is interesting to reflect on the relationships between the teacher's values and beliefs about teaching and their interpretations of the curriculum materials in influencing their perception of the curriculum as ends-based or emergent, and the style of pedagogy they employ in interpreting the curriculum materials with their students. I believe this holds for teachers' interpretation of any curriculum with the added dimension here of being asked to teach outside their subject specialism as a further factor to weave into the relationships. Non-science teacher's beliefs about science, as well as about education, pedagogy and Opening Minds, play a part in the way they approached teaching the CASE lessons. For example, as touched on earlier in quotes from Declan and Daniel, science, and in particular the CASE approach to science, is often seen by the non-science teachers as prescriptive, in terms of the language used and the concepts to be learned.

...There's a lot of specific language and again, it's all that thinking.(Daniel)

...there was science bits we taught that weren't so successful, personally. I found that quite tricky teaching the science side...[because it was], prescriptive. In terms of the fact that you had to use specific words to describe specific things. And whenever you describe a specific thing you had to use this word. And to me as a historian and somebody who likes their words, that was not great. And, I mean, A-levels I did maths and physics and geography as my A-levels so it's not like I can't get my head around science. But it was just this idea that, and the words didn't make sense to me and I can't remember what they were now but it was. (Isaac)

In this extract, Isaac explains that his sense of the lessons as prescriptive was not due to a lack of confidence in the subject itself, emphasising his qualifications in science. However, teacher confidence did appear to be a factor in influencing the teachers' use of the CASE

materials in Opening Minds. Both Daniel and Declan noted teacher confidence as an issue in incorporating the CASE lessons.

It just lacked, I don't think we were as confident as we needed to be with it. So we're going to have to do something with that. (Daniel)

And we weren't confident enough as a team about some of what we were explaining because we had a ten or twenty minute training session on it and then we went and delivered something that was relatively alien to us. (Declan)

In terms of science in comparison to teaching other specialist subject areas, it is interesting that in this data, teachers were less confident in teaching science than in teaching other material that was outside their subject area. The reasons for this lack of confidence are not clear, but may potentially be related to this sense of science as prescriptive, with its own special language, making it in some way 'harder' than the other subject areas included in Opening Minds. This sense of science as 'special' is also apparent in the science teacher's discourse about science, related to the misconceptions that can be 'tricky' to overcome for students and teachers (Matt); the sense that it holds a particularly important place in the core curriculum (Louise); and the sense that the skills needed to do and understand science are more specific than in other areas (Jacob). I take up these ideas in my discussion of the data through a complexity thinking lens in chapter 7, using concepts of relational identity to explore the science and OM teachers' ideas about science as a discipline. I also relate these ideas to the concept of interdisciplinarity from a complexity perspective, because the data here suggests that science was one aspect of Opening Minds that was, in this case, difficult for teachers and students to approach from an interdisciplinary perspective.

A further aspect related to teacher confidence in relation to teaching science can be linked to the notion of the authority of the teacher. Many of the teachers, both science and OM, appear to believe that specialist subject knowledge is important to lend authority to the teacher and ensure that the subject is being taught correctly. This general view contrasts with that of Toby, that all teachers should have the pedagogical skill to teach the 'basics' in any subject. It also contrasts with Isaac's view, expressed here, that it is alright if the students are more confident in the subject than the teacher and can enjoy and learn in any case,

It was very tricky as a non scientist to be teaching those [CASE lessons] in a room with the kids and, well in several cases the kids were teaching me and it was great! I mean, I'm not threatened by that at all I actually loved that . And they did too, they were really liked the idea that I didn't know what I was doing and they knew better than me which was great. But I did find that very tricky to teach. (Isaac)

In many cases, the OM teachers felt that they would have been more confident teaching OM if they had had more training in the CASE lessons and pedagogy, echoing the point made by Matt that CASE is most effective when taught by someone who was properly trained, such as the teaching assistant who was the science department's 'CASE Queen'(Louise).

We didn't really understand CASE but we I don't think we had sufficient training in trying to put it out there we all struggled with it quite a lot. And you know, it took a lot of preparation to make it work...if you think about what CASE is teachers go out and in order to do it they go and do INSET on it for 5 days we didn't do that, we just had our...and it's not through anybody's fault, its mostly through lack of time, lack of money having to get 6 people out to do a course. (Daniel)

Alongside a lack of training, teachers felt that they were asked to teach CASE with insufficient resources due to the way the lessons were timetabled, which was frustrating for both students and teachers and led to adaptation of the OM curriculum so that parts of the science were missed out. This missing out of some science elements in the first year through, and missing all the CASE materials completely in the second year, contributed to the negative perceptions of OM amongst the science teachers.

And the debrief, the kids, it got a bit messy and you know, they were standing around and they're; you'd get kids doing a demonstration but everyone wanted to do it and they couldn't because we didn't have enough kit and it was a bit frustrating...And I think [sigh] a lot of us kind of missed out bits deliberately because we tried bits and just on a practical level there wasn't enough equipment to go round for all the tutor groups being timetabled at the same time. (Declan)

We have got to make a plan as to what we are going to do and how we are going to do [science in OM]. Because it's kind of resource heavy (Daniel, speaking at the beginning of the third year of OM)

The influence of a lack of resources and training on the teacher's adoption of science into the OM curriculum could be seen as a form of complexity reduction, since it limited the students' engagement and ability to ask questions and experiment with the science materials during the CASE lessons. The removal of CASE lessons from the curriculum can also be seen as acting to reduce the complexity of the students' experience in terms of

limiting the subject materials they engaged with during the curriculum. In this case, the relationship between science and Opening Minds is also interesting to explore using a complexity interpretation of the concept of power, as the data shows that there are multiple ways in which the interactions between these departments enact power relationships. These relate to the different perceptions of science as a subject and how it can be incorporated into the OM curriculum, how teachers and students interact in the science elements of OM, and how decisions about the science and the OM curricula emerge through the trajectory of the case.

6.4.4 Summary of relationship between science and Opening Minds.

The findings presented in this section showed that the relationship between science and Opening Minds contained numerous tensions. These related to the different teachers' perceptions of the curriculum in both areas in terms of their beliefs about what the purposes of education are and how these translated into the development of the Opening Minds curriculum. In previous sections I have discussed how Opening Minds was viewed in terms of curriculum and pedagogy as something that had the potential to be different: more flexible, more open-ended, based on creativity, questioning and reflection. Although it is possible to view *science* as flexible, creative, open-ended, questioning and reflective, this is not the perception of science that is apparent in this data from the perspective of either the OM teachers or the science teachers. In the following chapter, I will explore these relationships using complexity thinking. I take up concepts of teacher identity and agency from a complexity perspective and use them to rethink the potential of both science and Opening Minds, exploring how ideas of emergent and mechanistic change might be useful for teachers working in the sorts of territories explored in this case. I also explore the data in relation to concepts of interdisciplinarity using ideas of relational and temporal emergence and complexity reduction to reconsider how the discipline-specific and cross-curricular elements of the curriculum might interact in potentially useful ways.

6.5 Analysis and interpretation summary

In this chapter, I have explored the bricolage of data collected in this case study, basing my discussion around four themes identified through the open coding of the data. Within each of these themes, I have used the theoretically driven analysis to relate the data within these loose, open codes to ideas drawn from my theoretical framework, including concepts of

relational and temporal emergence and complexity reduction to think about the data from emergent or mechanistic perspectives, along with concepts of agency, identity, reflexivity and power as I have approached them using complexity thinking. I have also paid attention to the way interactions within different parts of the school system have contributed to the emergent curriculum trajectory explored in this work. Throughout, I have shown that there were tensions threaded throughout the unfolding case study that can be linked to different concepts of emergent and mechanistic approaches to education and change. Perhaps the particular findings in this case in relation to the changing curriculum and the ways teachers negotiate the new curriculum and pedagogy in comparison with their usual experiences are not surprising in themselves. Despite this, I feel that the work in this case is interesting in itself in terms of the teachers' clarity of desire to work in innovative ways that have the potential for a radically different approach to education, even if this is not always played out in practice, and in terms of the findings about science education in relation to these sorts of innovation. However, the distinctive contribution to knowledge in this thesis is in the interaction between the case study as outlined in chapters 5 and 6 and the particular theoretical concepts with which it is explored in the next chapter, leading to alternative conceptions of how teachers engaging with this sort of innovative curriculum change could usefully approach the tensions between 'emergent' and 'mechanistic' approaches.

Chapter 7 Discussion

7.1 Introduction

In this chapter, I explore the case study outlined in chapters 5 and 6 using the theoretical framework of emergence and complexity reduction and the concepts of temporal-relational agency, identity, power and reflexivity I developed in chapter 3 using this 'complexity thinking' approach. Earlier, I developed my approach to complexity theory in this thesis using concepts of emergence and complexity reduction. I explored emergence as both *relational* and *temporal*, arguing that the concept of emergence in the complexity theory literature includes both of these aspects and that separating these interwoven elements highlights the emphasis on time as well as organisation that is important for a complexity thinking approach that draws on the logic of *strong emergence* as outlined by Osberg and Biesta (2007). Alongside the notion of emergence, I developed an understanding of complexity reduction, associated with mechanistic change and with a return to equilibrium. However, drawing on Biesta (2010a) and Rasmussen (2010), I argued that in studying a complex system, complexity reduction can never remove the potential for unpredictable and emergent behaviour, and acts that reduce complexity will also have the potential to trigger complexity in *different* and not anticipated ways. Using these three constructs in complexity to explore concepts of agency/structure, identity, power and reflexivity, and vice versa I developed an approach in which all of these concepts are seen as both relational and temporal. In this, I drew heavily on Emirbayer and Mische's work in relation to agency (Emirbayer and Mische, 1998) to develop a line of argument that I then built on in relation to the other concepts, which I see as weaving together with each other. Interactions within systems enable the emergence of structure, agency and identity within a network of power relations and reflexivity: all of these concepts are understood as being enacted within relationships and not the properties of individuals. As such, emergence is always possible even where power and reflexivity can be seen as acting in ways that might reduce complexity as actors engage with the system in 'mechanistic' ways. This is because responses to power and reflexivity in relationships always has the potential to create new and unpredictable enactments of agency, identity, or even ultimately emergent structures.

Bringing the empirical findings in the case study together with this complexity thinking theoretical approach, I use this discussion to explore the ways complexity theory enables us

to address curriculum change and pedagogy in different ways. I begin the chapter with a discussion of the tensions found in the case study, and highlighted in my analysis and interpretation of the case offered in chapter 6. I use concepts of the 'mechanistic' and the 'emergent' to explore the findings from the perspective of complexity. My exploration of the case indicated that the interactions between what might be deemed the 'mechanistic' and the 'emergent' were complex and interwoven and cannot easily be separated. I examine these tensions using complexity-framed notions of agency, power and identity to consider what this analysis might offer teachers working through curriculum change.

I then elaborate on these ideas using two key aspects of the case study as I formulated it - reflection and assessment in the new curriculum, and the relationship between the new curriculum and the science curriculum as 'traditionally' constituted within the school. I show the different and changing ways 'reflection' was constituted in the case study as the new curriculum developed, and discuss how a complexity thinking view of reflection as a form of assessment may enable teachers working with a new curriculum such as *Opening Minds* to engage differently with the problems of assessment in an emergent educational context. Finally, I explore the interactions between science and *Opening Minds* from the perspective of teacher agency, power and identity as the teachers in these different groups negotiated the curriculum change. Drawing on this interpretation, I discuss the implications of a complexity thinking perspective for science education in both disciplinary and interdisciplinary modes of teaching and learning. The discussion in this chapter therefore picks out some particular ideas that emerged through my work with the case study in order to draw out some aspects for further exploration. In this way, this chapter handles the complexity of the case by 'seeking out a balance between attention to and ignorance of detail' (Davis and Sumara, 2006 p. 160). In order to be able to say something, and in doing so open out further spaces for exploration rather than summarise answers, the research reported in this thesis and discussed in this chapter cannot be a complete discussion of all the threads of the case study that could be followed up. Instead, I use the case study as a ground to explore some ideas, creating a 'research report and a theoretical account that must be considered [as a form] that contributes to the shape of possibility' (Davis and Sumara, 2006 p. 161).

7.2 Mechanistic and emergent approaches in tension

In a recent discussion of curriculum change in a similar context to this research, Priestley highlighted what he sees as a ‘paradox of innovation without change’ (Priestley, 2011 p. 1), pointing to a pattern in education where constant policy-driven change requires innovation from teachers, but despite this innovation there is significant stability in school practices. He explores this paradox in interesting ways using Archer’s social theory, in particular the interaction between structure, culture and agency. In Bridge Community School, some similar patterns were found, with teachers experiencing tensions resulting from their attempts to be innovative with the new Opening Minds curriculum combined with a need for stability in maintenance of structures, roles and their responsibilities as teachers. The complexity thinking lens adopted in this study allows these tensions to be explored in different ways, thus building on Priestley and others’ work in engaging with educational change by taking a different perspective on agency, structure and culture informed by concepts of emergence and complexity reduction, as described in chapter 3.

A major broad pattern in the findings was that teachers’ values and beliefs relating to the aims and purposes of education in general, and the new curriculum in particular, were often held in tension with their enacted identities and their understanding of their roles and responsibilities as teachers. Open coding of the data identified a series of related codes in which teachers identified their aspirations for the new curriculum that were distinct from the traditional, subject-based curriculum previously taught in the school. These included their feeling that *‘education should be about thinking and questioning’*, and that Opening Minds should be *‘different from anything that had gone before’*, *‘looser and less constrained’*, *‘break down the barriers between subjects’*, and *‘be about process; like metacognition, questioning, student discussion and reflection’*. Broadly, these aspirations could be interpreted as affording the potential for emergent learning, in contrast with notions also expressed by the teachers, that *‘education should be about developing skills and knowledge’*, reflecting an outcomes-based, mechanistic view of education. However, examining each of these open codes in more depth reveals that it is not a simple story of some aspirations and activities being open-ended and emergent and others being mechanistic. Digging deeper in to these patterns in the data shows that the way the teachers express ideas about, for example, student questioning within the new curriculum is

also held in tension. As they attempt to shift their thinking towards more open-ended curriculum and pedagogy and a conceptualization of themselves as facilitators, enabling students to 'run parts of the lesson themselves' and decentralizing classroom authority from themselves to the students, they found significant challenges to their own identities as teachers and the responsibilities they understood within that role, alongside challenges from other teachers within the school who maintained more traditional beliefs about education. These patterns in the findings indicate that tension between mechanistic ways of thinking and emergent approaches is apparent in the data across a range of levels and weave together through the trajectory of the case. In the following, I focus on the complexity-framed concept of temporal-relational agency to discuss these tensions in the case, as the tensions within the framing of Opening Minds can also be considered by examining teacher and student agency in interaction. This is interesting because many of the ideas about Opening Minds that are seen as different or innovative can be linked to a notion of 'facilitation of student agency'. This in itself may appear to be a concept linked to approaches which might 'foster' emergence, but the data shows that even here, both mechanistic and emergent thinking are found.

In the OM curriculum, the teachers' desire to facilitate student agency can be found in the data in their descriptions of the idea that OM should enable the students to be independent, ask questions, reflect on their own learning and 'run the lessons themselves'. In a sense, these ideas seem to be about empowering the students in relation to their own learning. As I discussed in chapter 3, concepts of power and agency within a complexity framework are not seen as properties of individuals, but exist within a network of relationships of which the individual is a part, and are enacted through interactions with others. This suggests that aspects of teachers' ideas about OM that can be viewed as 'facilitation' or enabling the students to 'develop themselves' (Kate), 'take control of the lesson' (Declan) or 'raise their aspirations' (Daniel) must be enacted in relation to the students themselves, and that the students' responses in taking up these ideas can be seen as a further expression of student agency. Interestingly, the students' enactment of agency may not be in the direction the teachers' anticipate. This can be traced through various elements of the data described in chapter 6. To articulate the interactions between teachers and students in relation to the idea of agency, I will draw on two aspects of the data: the

tensions in conceptualisation of learning skills with facilitation of student agency, and the tensions in ‘managing’ the students with facilitation of student agency which is encapsulated in the slogan ‘Opening Mouths’.

7.2.1 Tension between facilitation of agency and learning skills

In the introductory chapter of this thesis, I outlined the curriculum context for the research, focussing in particular on the place of ‘Learning to Learn’ (L2L) and ‘21st Century skills’ in the new curriculum. To some extent, this constituted a change in balance in the National Curriculum from process to content, but in both cases, the dominant discourse is about learning that is assumed to be learning *something*, with the curriculum change relating to whether that something is learning or skills. In the Opening Minds curriculum in this case, this assumption also holds in the articulation of the purposes of OM. In my findings, there are differences in opinion about what skills the students should be learning: for some teachers they were specific skills such as graph-drawing or Braille, for others, they were skills of metacognition or the ability to work well with others. However, the findings also show that the Opening Minds curriculum developed in this case had the *potential* to unsettle the assumption that learning is simply about learning skills or knowledge rather than engaging with something in ways that might allow something unpredictable to emerge. This was apparent in the ideas discussed particularly by Declan and James about the ways they wanted the curriculum to be innovative, different and creative, related to the students having more freedom to take the lesson in directions *they* wanted. It is also apparent in the data where teachers discuss their responses to students’ actions in lessons in ways they had not anticipated, for example, in one lesson observation Sarah explained how a lesson went in an unexpected direction when one of her students brought a dead rabbit out of their bag during a presentation on spiritual artefacts.

The emergentist notion that the learning is about classroom engagement in ways that allow something unpredictable to emerge is found in Biesta’s discussion of what he calls a ‘pedagogy of interruption’ acting within an educational relationship (Biesta, 2006). This concept is related explicitly to complexity theory by Biesta and Osberg (2008), who conceive the educational relationship as a ‘space of emergence’. In this space – Biesta’s ‘gap’ between teacher and student (Biesta, 2004) – the interaction between teacher and student can enable the emergence of unique human subjectivity on the part of the student, but also

on the part of the teacher. The responsibility of the teacher becomes responsibility not for enabling the student to acquire particular skills or knowledge as an end in itself, but for acting in ways that enable the student to encounter difference, things outside their experience, so that they both construct new understanding for themselves and emerge as unique subjects. From a complexity perspective, this 'pedagogy of interruption' has the potential to interrupt a mechanistic and linear approach to learning through emergence of something unpredictable - the emergent interrupts the mechanistic.

The concept of nested levels within a complex system suggests that this argument can logically also be applied to collectives within a system as well as to individuals, meaning that it is possible to use the notion of the space of emergence in the educational relationship in the context of relationships between individual teachers and students, but also between teachers and groups of students, or between groups of teachers and groups of students, and so on. This means it is feasible to consider the educational relationship between a teacher and their tutor group in this way, for example. In the case study, we see examples of both mechanistic and emergent learning occurring in these educational relationships, in which relational agency plays an important role. Biesta argues that 'a theory of education is...a theory about the educational relationship. It is *not* about the 'constituents' of this relationship (i.e. the teacher and the learner) but about the 'relationality' of the relationship.' (Biesta, 2004 p. 13). Conceptualising agency as relational is a step towards theory about this relationality.

I argued in chapter 3 that, building on Emirbayer and Mische's multidimensional view of temporal-relational agency as iterative, practical-evaluative and projective, a creative dimension to agency linked to emergence should be added. This emergent, creative dimension of agency can be seen as 'interrupting' the iterative-projective dimension that would form a mechanistic approach. We can see in the case study data that the tension between an ends-based approach to learning skills, or 'learning to learn', and more open-ended approaches related to the teachers' desire to facilitate students in enacting agency illustrate the interactions between these dimensions of agency in the educational relationships of the case. The data shows that teachers spoke about the need for students to develop particular skills as learners, and these beliefs were borne out in the schemes of work they produced and in the lessons they taught. These skills included the capacity to

work well in groups, which they taught through ideas like encouraging students to use De Bono's thinking hats, or the capacity to identify the level of challenge they are experiencing and act in appropriate ways, taught through concepts such as the 'challenge zone' and 'stress zone'. These ideas relate to an ends-based conceptualisation of education, where the teachers drew on their own experiences in the past to plan how they might develop students' skills in 'learning to learn', combining iterative, practical-evaluative and projective dimensions of agency which they enacted through their interactions with each other in planning and designing the curriculum, and with the students during the lessons. At the same time, the enactment of the curriculum in this way entailed enactment of student agency within the relationship, as students also draw on similar dimensions of agency related to their experiences to translate these ideas and enact them within the lessons in relation to the teachers and to each other. In this way *both* teachers and students may act in ways that relate to 'mechanistic' approaches to education, as students are also familiar with the mechanistic, ends-based structure of education and may interact agentially in classroom situations that build on these past experiences and project them into future actions. However, as mentioned earlier, Opening Minds has the potential to unsettle this ends-based educational approach through what can be seen as a 'pedagogy of interruption', and the creative dimension of agency is a key element in this unsettling and interruption. For example, observing James' tutor group, 7J9, in preparation for the 'OM Olympics' showed ways in which they had taken the activities in directions that were not guided by achieving particular goals or learning particular skills. As James discussed, this feels 'risky'. In competition with other tutor groups, 7J9 took part in various activities requiring them to use and develop their 'learning skills', such as creating a presentation and designing a rocket. The students showed a form of creative agency in interaction with each other, interrupting the 'task' particularly in negotiating the role of an autistic student in the class in such a way that he took part with others, but on his own terms. In this sense, James enabled the students to enact agency by experimenting and inventing new possibilities within the framework of the new curriculum. Here, rather than facilitation of student agency being related to achieving goals such as the skill to work well with others, James facilitated a more emergent and creative enactment of the creative dimension of agency in his relationship with the tutor group as a whole and the individuals within it. Similarly, the use of reflection within OM showed the potential to enable emergence through creative agency woven into

an iterative or mechanistic approach to reflection, and I address this example in detail in section 7.3.

In the unfolding of the new curriculum, then, we can see that both mechanistic *and* emergent approaches occurred simultaneously within the educational relationships in this case, and that this occurs at the level of the Opening Minds team and curriculum, and at the level of individual teachers interacting with their students. Lavery neatly summarises Biesta's concept of the pedagogy of interruption that 'educators must teach students knowledge, skills and values *as they create opportunities for their teaching to be interrupted*' (Lavery, 2009 p. 573, my emphasis). As argued above, interpretation of the Opening Minds curriculum in this case through dimensions of relational-temporal agency that incorporate both mechanistic and emergent elements shows one way in which this can be achieved in practice. However, the findings in this case also show that working in this way is a challenge for teachers, as they can struggle with tensions in negotiating both the mechanistic and the emergent within their educational relationships in terms of their identities as teachers. This is particularly the case in relation to 'class management', and in the next section, I examine the tensions found in the case between open-ended ideas about education and the need for teachers to 'manage' the students and suggest that interpretation of Biesta's pedagogy of interruption in the context of a complexity-informed understanding of temporal-relational agency has the potential to support teachers in translating ideas about creativity and freedom in the curriculum into practice.

7.2.2 Opening Minds, Opening Mouths

The findings in this case show that the teachers involved in the new curriculum had to find a balance between creating and enacting a curriculum that tied in with their values and aims for the curriculum in encouraging students to think about their learning, understand their own processes of learning and ask questions of their teachers. It was recognised that this approach could not become simply an 'anything goes' way of working (like the 'unguided learning' discussed by Osberg and Biesta (2008)), as the teacher maintained a responsibility for planning lessons, managing the behaviour of the students and being accountable to the school leadership and to parents for the activities and learning taking place in the classes. For example, James' passionate description of the importance of what they were trying to do with OM was counterbalanced with the comment that 'obviously that doesn't always

happen in practice I would say, because you've got other things like classroom management...' and Declan explained how, as the leader of OM, he was at times frustrated by the amount of progress checking by the headteacher and by governors. As well as making day-to-day decisions on activities and the amount of guidance or freedom given to the students, the results show that the teachers' interactions with the students as a class or as a year group also influenced the way in which they approached teaching the new curriculum as it developed over the first two years. The narrative offered by the majority of OM teachers included an account of the boisterous and questioning attitude of the students in the first year of Opening Minds, gaining the curriculum the nickname 'Opening Mouths', with teachers describing students as 'loud, active and busy' (William) and also as 'cocky and arrogant' (Isaac), with traits that they felt needed 'careful channelling' (Declan). This is contrasted with the year group in the second year who were characterised as 'a good year group' (Isaac) and 'mellow angels' (Daniel) and with whom they were able to do work quietly and independently for longer periods than would have been possible with the group in year one.

It is interesting to examine this comparison from a complexity perspective because the teachers in the case were responding to differences in the year groups, differences in the tutor groups and individual differences but tended to characterise all of the students in each year group with a 'group' characteristic to which they responded with the curriculum trajectory. The response by teachers to a collective rather than to individuals highlights one of the ways that the nested nature of complex systems enables interactions in the case to be considered at different levels. Further, the concept of 'Opening Mouths' was seen as problematic within the case study, which is interesting as the students' voices, and enactment of agency in ways that were seen as unpredictable, was also viewed as problematic by many teachers within the case, including OM teachers. The interaction of teachers and students and enactment of agency, identity and power within that interaction led in this case to an emergent curriculum trajectory that shifted towards complexity reduction and mechanistic thinking. Again, this is explored in more detail in terms of assessment and reflection in section 7.3.

The teachers' characterisation of the students and the way in which they responded to the curriculum was often described as being about the students rather than about the

curriculum, but it is also clear in the findings that the teachers adapted the activities and pedagogy they used from one year to the next and that one of the influences on these choices was the perceived need to provide more structure for the students as a form of resistance to the 'opening mouths' class management issues, and because it felt more appropriate or possible to use different activities with the 'quieter' students. A similar pattern of a shift towards a more structured and 'managed' pedagogy was both observed in lessons and described in detail by Kate, who had a class who were felt to be rather too 'questioning' of teacher authority around the middle of year two of OM, and who she worked with in a style that controlled the class and asked them to work quietly and individually for one of the topics in a more traditional style. The notion of teacher authority and responsibility is an important part of the identity of the teachers in the case study in relation to the students and in relation to other teachers, as they felt that part of the teacher's role is to inspire and engage students but also to structure the learning for them and manage the class appropriately, something that can be identified as the 'socialisation' work of schooling. The relationships of power can be seen in the data in the language used by teachers about 'handing control of part of the lesson to the students', implying the teachers have choice about how much control to hand over. This is a power *relationship*, as can be seen in the way the students relate to this construct of power or to some extent challenge it in their 'opening mouths'.

However, the picture of complexity reduction in response to 'opening mouths' is complicated by the fact that the teachers felt that the 'quiet' year group were more difficult to get going, to 'get zingy' (William) and discuss their ideas and that OM was harder work for the teachers because 'you weren't getting diversity and you weren't getting discussion' (Daniel). This suggests that in the context of the OM curriculum, discussion, and through this unpredictability, were important elements of the teacher-student(s) relationships in which agency, identity and power are enacted. To engage in such discussion, students needed to open their mouths *in order to* open their minds. This can be related to the emergence of their own identities or subjectivities, and constructions of their own meanings, through enacting a creative dimension of agency in the student-teacher relationship. Within this 'opening mouths/opening minds' relationship, teachers were also confronted with an 'other', something unexpected or outside their habitual teacher-student interaction which

has the potential to unsettle or interrupt their habitual construction of their identity as teachers and lead to emergence of a new 'teacher identity' with this relationship. This negotiation of teacher identity in an emergent teacher-student(s) interaction means that the teacher *also* enacts a creative dimension of agency in the relationship, which can be challenging and unsettling for teachers working with a new curriculum like Opening Minds. The findings in this case show that whilst teachers recognise the importance of this kind of activity within Opening Minds, its challenge to habitual, mechanistic ways of working mean that OM teachers may also choose to enact iterative, practical-evaluative and projective dimensions of agency in ways that potentially reduce complexity and close down some possibilities for this challenge within the relationship, as shown in Kate's description of her actions to manage the questioning behaviour of her class. The reaction of other teachers in the school to 'opening mouths' is a further interaction influencing the OM teachers and students within the case.

This story within the data is one in which the teachers appear to be employing strategies to reduce the complexity of the system when they perceive a stronger need to manage the class and exert authority (for themselves or on behalf of other teachers in the school) compared with their desire to encourage agency and an active role in their own learning on the part of the students. In a sense, this is a clear example of a shift towards a more mechanistic approach to the curriculum, where, through processes of complexity reduction, there is less freedom for the students to create their own responses to the curriculum – to act with creative agency - thus reducing the capacity for emergent learning for individual students or for the students as a group and promoting a mechanistic approach in which learning and behaviour are directed towards particular goals and objectives outlined by the teacher. However, the picture is more complicated than such a simple trade-off between emergence and complexity reduction, as is shown by the teachers also working to encourage discussion amongst the students and facilitate student agency where they felt the students were almost too 'good' to question the teacher and each other and have the confidence to put forward different ideas. Looking at the way in which the teachers balanced discussion, questioning and unpredictability with individual work, structured activities and predictable, traditional approaches using the concept of relational agency shows that the interactions between teachers and students (the way they enacted agency

through their interactions) shifted in relation to each other, with the actions taken by teachers to exert more control interrupting and changing the actions of the students, and vice versa. However, it is important to note that although the shift from open to closed pedagogical approaches may appear to reduce the complexity and the unpredictability of the system, the possibility for emergence is always maintained *through* the relationships within the class, where there is always *potential* for an unexpected, creative agentic response in relation to an 'Other', be it the teacher or another student in the group. This leads to an interesting point, highlighted by the data it was and was not possible to collect in this study: that of interactions revealed between different levels of the system, and interactions that remain hidden in the findings available.

The description of the teachers' responses above characterises students at the level of the year group and at the level of the teachers' class, with teachers creating more structured curricular responses to the 'Opening Mouths' perception and particular structured pedagogies in response to their perception of their classes. This suggests the potential importance of temporal-relational agency between teacher and class, teacher and year group, OM team and year group and so on, as well as the action of temporal-relational agency between individuals. What is lacking in the data is information about the potential for emergent learning and curriculum activity that may have developed through the teachers' individual interactions with students where, perhaps during a more structured lesson from a whole-class perspective, the teacher takes the time to 'sit down and chat to them one-to-one' (William). This means that it is not possible within this research to comment on the particular interweaving of emergent and mechanistic effects on the curriculum at this individual level, whilst at the same time the research does make it possible to highlight the complexity of such interactions which may take place at different nested system levels as well as in relation between teacher and student.

Davis and Sumara (2006) discuss this nested complexity and decentralised control within complex systems in ways that are relevant, here. The diagram in Figure 13 shows nested levels of schooling, in which each region flags a coherent complex phenomenon that can emerge from a decentralised network structure as shown in Figure 14. Davis and Sumara discuss how complexity theory prompts attention to classroom knowledge and curriculum structure as well as to individual knowledge in relation to disciplinary knowledge, but they

note that this means that ‘any attempt to understand an educational phenomenon must be understood as *partial*’ (Davis and Sumara, 2006 p. 93).

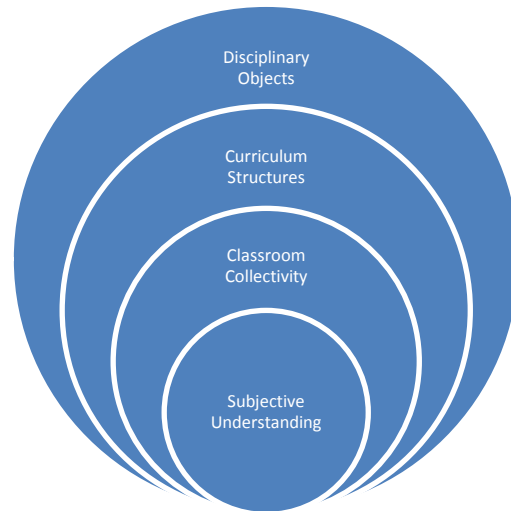


Figure 13: Nested levels of schooling, adapted from Davis and Sumara (2006).

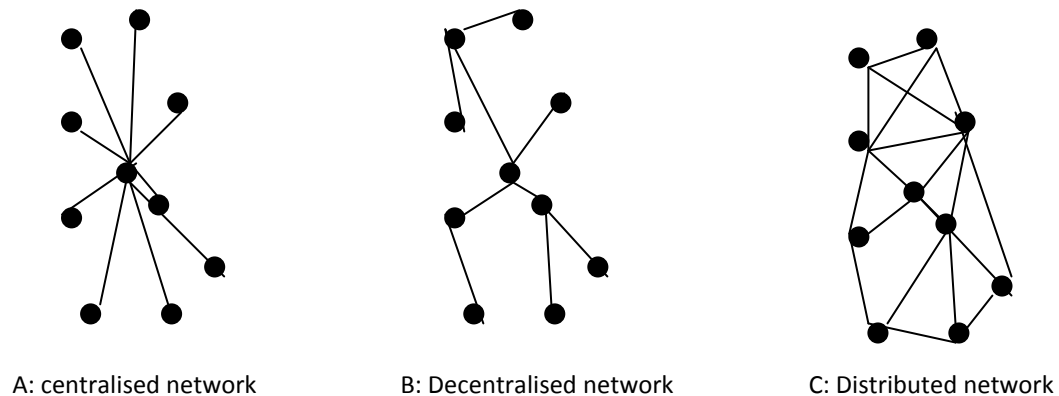


Figure 14: Network shapes, adapted from Davis and Sumara (2006) p. 52.

Linking these ideas from complexity theory to my case study, it is perhaps not surprising that a lack of detailed data examining the individual student-teacher relationship leads to a partial understanding of the case and focuses instead on interactions at the classroom collective and curriculum structure levels. Exploration of the data using concepts of centralised, decentralised and distributed network styles in the context of emergence and

mechanistic approaches within educational relationships adds a further interesting dimension to the analysis. The diagrams in Figure 14, adapted from Davis and Sumara (2006), show different kinds of network structures that may occur in schools, related to different distributions of teacher authority. They argue that potential for emergence is greater in systems with distributed control, and we can see that in such systems, there are greater numbers of relationships. In centralised, hierarchical systems, the teacher relates to each of the students, but the students are not able to interact with each other. In the case of Opening Minds, the teachers structured and re-structured the classroom networks, at times moving towards more centralised systems as a result of the challenges raised by ‘opening mouths’, as exemplified in Kate’s move towards more individual work with her class. However, although this meant a change in the interactions in the class or year group, and therefore a change in the possibilities for a ‘pedagogy of interruption’ through the action of creative agency via a form of complexity reduction, all of these types of network involve educational relationships and thus the potential for emergence or ‘interruption’. The nested nature of complex systems and the position of the teacher within them, interacting and co-evolving in the system at different levels of organisation, means that in the complexity of the interactions, mechanistic and emergent approaches may *co-occur* within the system, related to the action of temporal-relational agency, identity and power. This leads to practical implications for teachers working in the context of a changing curriculum that can potentially be oriented towards emergent and creative ways of working that could be deemed ‘contingently responsive and creative teaching’.

7.3.3 Contingently responsive and creative teaching

Previously, I have discussed the ways both mechanistic and emergent elements were found in the Opening Minds case study in ways that are difficult to separate, and considered how these elements were enacted with the educational relationships in the case. Drawing on Biesta’s discussion of a ‘pedagogy of interruption’, I discussed how this type of pedagogy could be seen in the data and considered how this relates to the multi-dimensional view of agency I developed in chapter 3, where I built on the work of Emirbayer and Mische (1998), in combination with the concept of strong emergence, to theorise an emergent, creative dimension to temporal-relational agency alongside the more mechanistic development that can be traced through the concepts of iterative, practical-evaluative and projective agency.

Similarly, a relational understanding of agency and power can be used as a lens to explore the data, as the Opening Minds teachers' identities shifted and emerged in relation to the students when, at times, they worked in enacting the curriculum in ways that interrupt standard classroom practices and the usual expectations of the teacher role. I also explored how these notions, which exist within a concept of an educational relationship, can be applied to a range of interactions within a nested complex system, drawing on Davis and Sumara's (2006) work.

These arguments suggest that in discussing this data, it is not appropriate to isolate mechanistic and emergent educational approaches, as they appeared to weave together. At the same time, the findings show that the teachers experienced challenges in enacting the creative, flexible and emergent dimensions of the curriculum because of pressures from their dominant mode of working in mechanistic ways, combined with interactions and expectations from other teachers with whom they worked and the school hierarchy. I argue that in cases of changing curricula such as Opening Minds, where the new curriculum has the potential to unsettle the ends-based conceptualisation of education, the complexity informed arguments above constitute a practical suggestion to support teachers in developing a 'contingently responsive and creative' approach to teaching. This phrase was suggested by Wegerif et. al in response to Inquiry-based Science Education (Wegerif et al., In preparation for 2012/13) and will also be explored in section 7.4. Such an approach needs to be able to combine the mechanistic and the emergent. Indeed, as Davis and Sumara note in their discussion of 'vital simultaneities', Derrida views such dichotomies and hierarchies as hallmarks of western thought, and a straightforward separation of mechanistic and emergent approaches within systems such as Opening Minds appears rather artificial in the context of this data. I therefore suggest that it is appropriate to consider the mechanistic and emergent as a 'simultaneity'. The notion of contingently responsive and creative teaching combines *both* mechanistic and emergent elements within teacher response to student(s) within the educational relationship. The complexity thinking approach here, and the conceptualisation of the creative dimension of agency as an aspect of a pedagogy of interruption, enables teachers to embrace the emergent aspect of their work *as well as* the mechanistic, rather than seeing closure and the achievement of iterative goals as the important purpose of their work. This encourages teachers to seek ways to enable students

to engage with ideas to create something new in the way they respond, whilst at the same time learning knowledge or skills. In the following section, I explore the concept of reflection in this case study in depth. Potentially, reflection can offer a way for teachers to engage in responsive and creative teaching and engage with students in emergent ways.

7.3 Tensions in use of 'reflection'

Overall, the Opening Minds curriculum trajectory that developed in this case was influenced by teachers' responses to the tensions discussed in the previous section and to the changing teacher-student interactions experienced as a result. Teachers described their initial excitement about the freedom the new curriculum could provide, with more space and time to do the things they believed to be important. The design and structure of the new curriculum was put in place to enable different sorts of teaching activities and different group structures, moving away from the constraints of the normal class and school timetable. In terms of pedagogy, teachers put in place more independent and group work, more opportunity for pupils to ask questions and discuss their ideas, and gave the notion of *reflection* as a key concept in Opening Minds a central position. However, during the first year of implementation, as the 'Opening Mouths' nickname arising from other teachers' concerns over pupils' attitudes developed in parallel with OM, teachers began to be concerned that they didn't have a way to assess the pupils' progress in OM, to show to the school management and the dissenting teachers that the new curriculum was effective. In the second year of teaching OM, then, although the broad thrust of the OM curriculum remained the same, the OM teachers put more structures in place to manage the students' learning and support assessment processes. As a broad pattern, we can see that the curriculum trajectory appeared to begin with an emergent phase, where the desire for difference, flexibility, and student choice and agency were dominant. As teachers experienced tension between these aims and the more mechanistic and structured approaches with which they were familiar, some changes were made to the curriculum which had the effect of reducing the complexity through, 'reducing the options for action...for elements within the system' (Biesta, 2010a p. 7). Once again, though, as discussed in the previous section, the story is not clear-cut, as emergent and mechanistic understandings of education and change weave together throughout the period of research.

An important strand within the data which is part of this curriculum trajectory is the use of reflection within the curriculum and the development of reflection as a tool for assessment.

The idea of reflection was a strong element of the new Opening Minds curriculum and was embraced by teachers as important in achieving their aims of helping students to understand their own learning. As the curriculum was developed, teachers saw 'reflection' as a way of enabling the new curriculum to *be* different and less constrained, and as a way of enabling students to have more choice and power in relation to their own learning. However, although the data collected throughout the research shows the ideals that teachers had for the emergent possibilities reflection might afford, it also shows that in practice, both teachers and students used reflection in often rather superficial and mechanistic ways. This problem did not go unrecognised by teachers, who were aware that they did not always have the time with the students to reflect in any depth.

Taking the case at a level of the curriculum trajectory, we see that initially, reflection was an important principle within the curriculum but was not tied to assessment – in fact, the teachers had not begun to think about how OM would be assessed in these early stages, which suggests that prospective complexity reduction through knowledge of assessment criteria was not a strong factor in the emergence of the new curriculum in these early stages. During the initial teaching of OM and resulting from interactions with the wider system as well as their own identity beliefs about the role and responsibility of the teacher (e.g. William's discussion of his introduction of half-termly reviews), the findings show that teachers became increasingly concerned with finding ways of assessing Opening Minds in order to fit in with the traditional school systems and expectations of management, parents, and their own beliefs. However, the traditional systems of assessment through a process of end-of-topic tests of knowledge and skills were not appropriate within the emergent curriculum environment. They had moved away from past assessment systems into an emergent situation where what had gone before no longer validated aspects of what they were doing, and so these aspects could not be validated using previous assessment systems. Hence, the need to produce a form of assessment that could be understood both in the context of the new curriculum and in the context of the traditional systems was a source of tension for these teachers, as a result of their interactions within the school system (between the OM team and the rest of the school and wider school community) and as a

result of the interaction between their new enactment of teacher identities in relation to Opening Minds and their enactment of teacher identities in relation to aspects of the previous system both in an iterative dimension linking their personal histories as teachers to their present actions, and in a practical dimension of their continuing teaching in the traditional subject disciplines which reflect more closely their previous ways of working. These tensions contributed to different ways of using reflection in Opening Minds. In the following discussion, reflection with the new curriculum is considered in four ways: reflection-as-process, reflection-as-interaction, reflection-as-assessment, and reflection-as-action. I discuss each of these elements using a complexity-informed perspective contrasting emergent and mechanistic ways of thinking about reflection in education.

7.3.1 Reflection-as-process

James, one of the lead teachers for OM, noted that reflection shifts the curriculum towards process and away from content, something which he valued highly. Many of the OM teachers talked about reflection in this way, as a process rather than an end in itself. Depending on how the process of reflection is viewed, it is possible to conceive of reflection-as-process as a pedagogical approach that can open space for emergent learning possibilities, linked to a shift in the understanding of learning that stems from a complex epistemology. A traditional view of learning identifies learning outcomes, where learning is an end in itself. In this mechanistic framework, the desired outcome can be identified along with a progression of steps to build up the knowledge and skills required to reach the goal. Finally, assessment against the outcome identifies whether that goal has been reached, and can be used to inform a decision about what would be the next sensible learning outcome in progression towards knowledge of a particular field. A complex view of learning moves the interest away from learning a particular something, and towards engaging with that something to open spaces for new learning to emerge, which may be in unpredictable and unanticipated directions. I discussed this in the previous section in relation to Biesta's 'pedagogy of interruption'. Reflection has the potential to be oriented towards such a pedagogy - one which pays attention to emergence - if the process of reflection such as that described by James is used to constantly open spaces for emergence (Osberg and Biesta, 2008), where students are confronted with a challenge to their current ways of thinking. However, reflection-as-process can also take a mechanistic turn, if the process of reflection

is simply viewed as looking back to review the successes and failures of a learning activity in order to do the same activity (or a similar one) better in the future. The findings in this case study show that despite the teachers' expression of a desire to foster creativity, flexibility and agency for the pupils, with reflection as a key element of the associated pedagogy, the more mechanistic conceptualisation of reflection-as-process described here tended to dominate through the adoption of particular structures and language used to support reflective practice in the case. These included the use of 'What Went Well' and 'Even Better If' as a simple language structure for reflection, alongside use of the OM competencies to reflect on their learning in relation to particular areas of learning and life skills.

The WWW/EBI language used within OM in this case does not in itself tie the process of reflection to a mechanistic framework, as the question, 'even better if?' could potentially be used to open ways of thinking in new and different directions. However, it seems likely that WWW and EBI are much more likely to remain tied to a step-wise, mechanistic orientation to education along a linear pathway, and this was the way in which it was generally found to be used in this case. For example, Declan's description of continued feedback and improvement using 'EBI' is a good example of the way in which WWW and EBI came to be used in the case to support the reflection-as-process in a mechanistic style. Declan felt that this reflective work was very powerful, but it is clear that the power was in achieving a particularly impressive outcome through reflection, feedback and re-drafting, rather than the process of reflection orienting towards new learning, if learning is understood as something that is not already known, or known to be good. This understanding of the process of reflection can be linked to the concept of Assessment for Learning (AfL), which has become increasingly important in UK schools since the turn of the century (Black and Wiliam, 2010), and which informed the research into Learning how to Learn undertaken in the influential TLRP project discussed above (James et al., 2006). AfL is an approach which encourages teachers to work with students to help them understand where they are in their learning and, crucially, what they would need to do to move forward. Student reflection, with support from the teacher, is a fundamental part of AfL and is an activity with which the teachers and students in this case study were very familiar. AfL encourages pupil self- and peer-assessment as well as teacher assessment, and promotes rich questioning and oral feedback as a way of monitoring learning to help teachers provide timely and effective

formative assessment. AfL provided a very important change away from a focus on assessment as summative and towards assessment as an integral part of the process of learning. From a complexity theoretical perspective, this move is an important one, as it highlights the importance of rich feedback within the complex learning system. However, complexity thinking would suggest that AfL is itself tied to a more mechanistic approach to learning and reflection such as the one found to dominate in this case, and that a further change in teachers' practice to enable AfL and reflection to be explicitly oriented towards emergent learning *as well as* mechanistic learning, would be helpful for teachers and students. A change in thinking in this way would contribute to explicitly acknowledging and engaging with the uncertainty and messiness of learning to support creativity and agency in classroom practice, rather than teachers feeling that such aspects of educational activity are less valid and can only be done once the main activities of education are achieved.

7.3.2 Reflection-as-interaction

Alongside attention to emergence, complexity theory also pays particular attention to interactions and relationships within the complex system. In contrast, reflection is often understood as an individual activity. Bleakley (1999) argues that there is a tendency for reflection to be introspective and seen as the individual looking *back* and *in* to their own actions and experiences. In this case, student reflection was regularly undertaken as an individual activity. For example, teachers asked students to reflect individually in their journals using WWW/EBI, or reflect on their learning against OM competencies that had been used as lesson objectives. However, such a view of reflection is too simple and, although this individual reflection did happen, reflection in this case was not restricted to an individual activity. Instead, reflection was undertaken as an interactive and collaborative process. Groups were asked to reflect on their learning both as a group and in conversation with other groups who provided feedback. Teachers worked with students through reflective conversations, with individuals, with groups, and through whole-class discussions. Reflective activity in the Opening Minds lessons became a form of classroom interaction and dialogue. Teachers themselves also engaged in reflection in interaction with other collectives in the system such as the staff as a body, the senior management and within the OM team. Reflection in the context of these interactions can be viewed as the kind of reflexivity Archer (2003) saw as mediating agency and structure, which I interpreted in

chapter 3 within a complexity frame as reflexivity that is a means by which different emergent levels of organisation interact. In this way, OM teachers' reflection in interaction with the other groups in the school influences how they enact agency and identity within these interactions, which could be in both mechanistic and emergent ways as discussed in section 7.2, and influence the range of complex interactions in the case and the *emergent trajectory of the case*.

This means that reflection as a form of interaction again shows the potential for emergent learning. Complexity thinking emphasizes the importance of interactions between actors within the system for emergence to take place (Davis and Sumara, 2006, Cilliers, 1998), with sufficient diversity between these actors. Following Biesta's conceptualisation of the importance of the 'gap' in the educational relationship as the locus of emergent subjectivity, it can be argued that through complex interactions with an 'other' who can offer a challenge to a student's current understanding, unpredictable new learning may emerge (Biesta, 2006). It then follows that when reflective activity is undertaken in interaction with others, there is potential for emergence. In the data, examples are found where reflection took place as an interactive activity which took learning in directions that were not anticipated by the teacher. A good example of this was in Declan's lesson, where the teacher responded to pupils' responses to the unexpected actions of one student with Asperger's syndrome by introducing a reflective discussion around their responses and interactions, leading to learning which was beyond that planned as the lesson outcomes and unanticipated by both teachers and students. In this case, emergent learning as a result of reflection-as-interaction was found. However, the preceding argument again relies on a conscious orientation towards reflection that embraces emergent possibilities, which the example of Declan's lesson exemplified, and which is in contrast to a more mechanistic approach. Once again, in general the findings in this case show that although reflection was not limited to individual work, it was dominated by a mechanistic conceptualisation of learning which asks students to 'look back' and then 'look forward' in time with a particular goal or learning outcome in mind.

The above discussion of reflection-as-process and reflection-as-interaction has shown that, from a complexity perspective, reflection has the *potential* to foster emergent learning but that it can also remain tied to mechanistic approaches to education. I now turn to discuss

reflection-as-assessment within this case, to consider whether a move towards a complex orientation to reflection as described in the preceding discussion may support teachers in resolving the tensions they experienced and offer a new way forward for thinking about assessment in relation to 'learning to learn'.

7.3.3 Reflection-as-assessment

As discussed above, the findings show how the teachers' perception of reflection within the curriculum shifted from a generalised notion of reflection as important in terms of their values and beliefs about education, with a crucial role in helping the students develop their skills as learners alongside a creative and questioning attitude, towards adopting particular aspects of language to support reflection. In later stages of the curriculum trajectory, this shift also included a move towards the use of reflection against the curriculum objectives (the RSA OM Competencies known as CLIPS) as a form of assessment of pupils' learning. The necessity to find ways of assessing pupils against particular identified outcomes (influenced by school management, their own understandings of teacher responsibilities, and the need to demonstrate the impact of Opening Minds) became a source of tension for teachers in the case study where this need contrasted with the desirability of the flexible and open nature of the emergent curriculum.

The Opening Minds teachers appeared to resolve this tension by using the students' reflections on their work, already incorporated within the new curriculum pedagogy, as forms of assessment. This included the use of written reflection using the WWW/EBI language or the OM CLIPS during plenary activities, which could then be taken in and 'marked' by the teacher using the CLIPS as marking criteria. It also included the use of OM review sheets at the end of a block of work, in a position that is more traditionally occupied by the end of topic test, which asked students to reflect on their learning during the topic, identifying for themselves which OM they felt they had developed and why, and setting themselves targets for future topics (thus combining the OM and the WWW/EBI reflective language). It seems that teachers within the new curriculum environment attempted to fit an aspect of the curriculum which they view as crucial – reflection – into positions within the school structures that are traditionally related to assessment. This occurred in ways that built on pre-existing practices of peer and self-assessment alongside teacher assessment that have been increasingly prevalent in UK education in the form of 'Assessment for

Learning' (AfL) and the various 'learning to learn' programmes which link student self-reflection to modes of formative assessment (see e.g. James et al., 2006, Black and Wiliam, 2010, Claxton, 2002). The analysis of the relationship between AfL and 'Learning How to Learn' (LHTL) practices and the challenges of assessing LHTL provided by Black et al (Black et al., 2006) are interesting to consider in the context of the case study presented here, as these influential discourses can be traced through to the Opening Minds curriculum created in this context, though the practices, pedagogy and curriculum created here are unique. It is the unique development of the new curriculum, through a combination of emergent and mechanistic (complexity-reduced) elements that is of particular interest here, and how the teachers in this particular case resolved the challenges of assessing their new curriculum can be interpreted through a complexity-theoretical lens which provides a novel perspective. Previous work examining the difficulties of assessing second-order learning such as LHTL and metacognition (Hoskins and Fredriksson, 2008) has considered the problem from the normative, Cartesian framework typical of education. If we use a complexity informed framework such as the one I have employed in this discussion, it may be possible to, if not create a system for assessing such skills, find a resolution of tensions to support teachers' and schools' practice in negotiating the possibilities.

The dynamic that developed at Bridge Community School as teachers worked to find ways of assessing in a new curriculum environment appears to have involved an intertwining of the evolution and adaptation of practices that existed already (stemming from AfL) with the emergent curriculum in which their previous modes of assessment were unsatisfactory. This pattern at the curriculum trajectory level was mirrored in the playing out of this dynamic within the classroom interactions over shorter timescales, where reflection was found as an assessment tool in which pupils self-assess and peer-assess their learning using mechanistic, outcomes-oriented practices but also through processes and interactions which have the potential for emergence and were occasionally seen in the data to take learning in unanticipated directions.

7.3.4 Reflection-as-action

A consideration of reflection in the context of curriculum change using ideas from complexity theory in the ways discussed above can help teachers in negotiating reflective practices such that they are able to use 'reflection' in a thoughtful and consciously flexible

and responsive way. In complexity theory, one important characteristic of complex systems is the existence of recursive feedback loops, which form non-linear connections between different parts of the system. Within a system such as the one examined in this research, 'reflection' can be viewed as one mechanism of recursive feedback within the system. A complexity framing emphasises that reflection, understood in this way, is a non-linear, interactive process which may result in emergent change, as the outcome of such reflective activity in complex interactions through space and time must be unpredictable (Phelps, 2005, Bleakley, 1999). In this way, reflection can act within the educational relationship to interrupt the mechanistic in ways that I explored in my discussion of reflexivity as both relational and temporal in chapter 3. This 'complexified' reading sees reflection-as-action within an educational relationship and requires a change in thinking to move away from a more habitual reading of reflection as a process of personal consideration of activity in relation to particular goals, with the aim of adapting future activity in order to achieve those goals, or of creating new goals which build on preceding successes or failures. In their creation and development of the Opening Minds curriculum, reflection appeared to be used in a more open-ended and complex style in the early stages of the changing curriculum practice. Reflection was used within the emerging pedagogy both individually and collaboratively and with a focus on reflection as learning (though, as described earlier, teachers experienced tension in attempting to use reflection as a learning tool that was both mechanistic and goal-based, and open and creative). The data shows that teachers used reflection consciously and unconsciously in their own developing practice, individually and with each other in their Opening Minds team, as well as reflection being a formal part of classroom practice undertaken by students individually and in interaction with their teachers and with other students. This suggests that reflection in this system was an important interactive process which played a role in curriculum change and emergence.

The formalised shift towards using reflection as a form of assessment entailed a move by the teachers towards conscious use of reflection within pedagogy which is mechanistic in approach so that assessment against objectives such as the OM competencies becomes possible via student reflection and self-assessment against these goals. This move, whilst emphasising a particular 'non-complex' way of thinking and acting as a potential complexity reduction mechanism, does not negate the wider reflective activity still taking place within

the system in both tacit and explicit ways. This wider reflective activity, described in complexity terms, enables emergence and ensures that simple use of reflection to assess learning (in relation to learning skills such as those found in OM) is problematic, as such an assessment process ignores the breadth of reflective activity taking place within the system and is unable to assess emergent and unpredictable learning. If a complexity thinking approach to reflection is adopted by the teachers in a system such as this, the tensions they experience in attempting to assess 'learning how to learn', learning skills or OM competencies could be, if not resolved, at least not ignored by focussing on complexity reduction mechanisms such as only acknowledging outcomes-based learning through linear assessment processes. Instead, an understanding of reflection as a relational and interactive process which may act in both mechanistic and emergent styles may allow teachers to consciously use reflection as a responsive and flexible approach to learning and subsequent 'assessment'. This would enable teachers to more confidently use different activities and language to structure reflective work in the classroom and school in ways that are at times mechanistic but also able to open out to enable and respond to emergent learning. This argument therefore develops reflection, understood in complex terms, as a crucial aspect of a pedagogy of interruption.

Using reflection in the ways described above is to use it to do two things; as a form of assessment of learning, and as a form of learning in itself. Conflating these two uses of reflection can lead to a lack of clarity for teachers and a complicated situation in which reflection is situated within the curriculum such that it is both a learning process and a way of assessing learning, an individual process and a collaborative one, a tacit process and an explicit one. *How* reflection is used as both a form of assessment and as a form of learning itself depends on what learning is understood to be. Assessment for Learning approaches locate assessment within the learning process, rather than something separate which takes place after learning, but this learning process is itself commonly viewed from within a mechanistic and linear framework. I suggest that Reflection for Learning might be an appropriate way of incorporating the emergent into classroom practice. If learning is reconsidered from a complexity perspective, the position and purpose of assessment must also be reconsidered. As learning becomes a starting point rather than an end point, assessment becomes a form of feedback about the complex learning system – an

exploration of the 'known' which forms the ground for exploration of the unknown, unpredictable and emergent.

7.4 Tensions between science and Opening Minds

In the introductory chapter of this thesis, I explained that changes to the national curriculum in England that led to the introduction of OM at Bridge Community School also included changes to the science curriculum. These changes included a shift in the balance of content and process in science education with greater emphasis placed on 'How Science Works'. In terms of the relationship between science and the Opening Minds curriculum, I highlighted earlier that the way science is related to the 'learning to learn' and 'learning for the 21st century' elements of the new curriculum is likely to be influenced by the way the nature of science is understood by teachers in the case. The findings in this case study show that the interaction between the science department and Opening Minds were problematic and that there were significant tensions between the two aspects of the curriculum for both OM and science teachers. In this school, for year 7, science was taught both by science teachers in the science department, and by non-science specialist OM teachers within the Opening Minds curriculum. It is therefore relevant to explore the relationships both in terms of interaction between the subject-based and cross-curricular elements of the curriculum and *within* the cross-curricular element that is Opening Minds.

An interesting way to approach these tensions is through discussion of perspectives on disciplinarity and interdisciplinarity drawn from complexity theory. As noted in the findings, Opening Minds was seen as a way of breaking down barriers between subjects, and this was supported by the science teachers interviewed as well as the OM teachers. However, there were differences in the way they felt such breaking down of boundaries should be achieved. Many of the science teachers focussed on OM working in cross-curricular ways to develop skills that could then translate in to disciplines in ways that maintain the bounded nature of disciplines with an added layer of cross-curricular element that can link these disciplines. Within OM, the focus was on topic-based teaching drawing on multiple disciplines, with teachers discussing the notion of 'subject lenses' as different ways of viewing phenomena to encourage students to make links between different disciplinary perspectives. McMurtry defined multidisciplinary as drawing on multiple disciplinary perspectives to better understand or address a certain issue or problem (McMurtry, 2011 p. 20), and this appears

to relate closely to the subject lens view of OM. In complexity theory, a notion of interdisciplinarity similar to Klein's understanding of transdisciplinarity can be found, which focuses on bringing together ideas from more than one discipline in ways that allow new perspectives and new ideas to emerge (Klein, 2004). Whether the subject lens notion in Opening Minds could be seen as interdisciplinary in this sense rather depends on whether the interaction between subject-based perspectives is used within the educational relationships to enable new perspectives to emerge for the students – to use the same language as in the preceding discussion in this chapter, the question is whether subject-lenses are used as part of a 'pedagogy of interruption'. There is perhaps more potential for this in the OM teacher perspective than in the science teachers' notion of translation of skills between subjects for which cross-curricular seems to be a better term, but within OM, the multidisciplinary label is most appropriate. Also, the data suggests that even where interdisciplinary work could occur in OM, science was typically seen as a separate element under the OM umbrella as the 'CASE lesson' was retained. This means that although a complexity perspective on interdisciplinarity might have been helpful for OM teachers in their ambition to break down subject boundaries, I need to expand the discussion further to consider the interactions between science and OM in this case.

Drawing particularly on the work of Davis and Phelps (2005) to highlight that interactions between disciplines often focus on either the *knower* or the *known*, McMurtry (2011) argues that complexity theory enables attention to be paid to both these aspects of work, refusing to 'collapse phenomena with knowledge of phenomena'. Complexity theory views knowers as complex, relating the knower to different levels of complex phenomena including the biological, social, cultural and ecological. This enables attention to be paid to the way an individual knower incorporates in their embodied history aspects of disciplines or professions which form part of their culture or socialisation. Taking this idea to examine the findings in this case study, we can consider the teachers involved as embodying particular unique histories depending on their disciplinary orientation, which will influence the way they enact their identities through the relationships within the case. A similar argument can be made at the level of the science department, which has an embodied history influenced by the discipline of science and the culture of school science. For Opening Minds teachers individually, there is a complex interaction between their embodied

histories and therefore identities as subject teachers alongside their emerging roles as Opening Minds teachers who teach 'learning skills'.

In this case, one of the key challenges found in the data was in the OM adoption of 'CASE' science lessons. These lessons, as explained in chapter 1, are designed to develop higher order thinking skills in science, developing pupils' understanding of particular scientific concepts and scientific thinking, such as the concept of variables in experimental design. Both science and OM teachers questioned the ability of the OM teachers to 'deliver' these lessons effectively. OM teachers found the language used in these lessons prescriptive and specialist and felt ill-equipped in teaching these lessons. They also highlighted issues with a lack of training, a lack of equipment, and a lack of personal knowledge. Exploring this through a complex notion of embodied history related to disciplinary knowledge, it seems that the OM teachers found it difficult to enact the identity as a science teacher that they felt these pre-planned lessons required, and which they attempted to therefore teach in relatively mechanistic ways and then ultimately abandoned. Within this broad pattern, individual OM teachers discussed different ways they worked with these challenges. Daniel described the need to 'OM' the science CASE lessons - to adapt them into the cross-subject style of OM. He suggests that, with support, these science subject lessons could be changed to tie in to the 'subject lens', flexible and creative OM pedagogy. Isaac took an approach that was different again, and happily explained that the students often knew more than him and were teaching him in these OM/CASE lessons. Since it seems that the discursive and questioning style with greater student freedom advocated as the OM style ties in with aspects of the nature of science, these ideas suggest some interesting possibilities for interaction between science and OM-style curricula, and I explore it further below. In doing this, I suggest that these aspects of science teaching would need to be able to adopt the woven mix of mechanistic and emergent approaches discussed already in this chapter in terms of relational agency and reflection within a pedagogy of interruption.

Alongside the idea of complex knowers, complexity theory engages with the complex nature of knowledge. In the case of school-based education, the relationship between 'disciplinary' knowledge held in the discipline of science, or in the interdisciplinary work of educational scholarship, and the knowledge of 'school science' or 'learning to learn' becomes an important aspect of this complex nature of knowledge. The relationship between scientific

knowledge, philosophy of science, and science as it is included in the school curriculum has been the subject of much research, in particular in relation to the nature of science where there is less consensus (Donnelly, 2006, Osborne et al., 2003a). Osborne et. al (2003a) found a consensus between science researchers' opinion about what school science should include around nine themes: Science and Certainty, Analysis and Interpretation of Data, Scientific Method and Critical Testing, Hypothesis and Prediction, Creativity (including Science and Questioning), Cooperation and Collaboration in the development of Scientific Knowledge, Science and Technology, Historical Development in Scientific Knowledge, and Diversity in Scientific Thinking. Comparing with an earlier review of national science curricula, they suggest that of these, only the theme of 'diversity in scientific thinking' did not appear in school science curricula. Indeed, examination of the science lesson observations in this case study show many of these elements, and many are also developed within the CASE approach that was transferred from science to OM. However, the argument that diversity in scientific thinking is relatively underdeveloped in school science compared with the field of the philosophy of science (Dupre, 2003) is also apparent in the data in this case, where science was viewed as relatively prescriptive and associated with particular language and rules. This missing link in the relationship between school science curricula and conceptualisation of science in the wider discipline may result from a combination of teachers' ideas about science not focussing on this diversity (related to their socialisation into scientific disciplines as discussed earlier) or from mechanistic approaches to education, including science education, that limit the possibility of developing this diversity. In this case study, there is insufficient information in the findings to be able to say if either of these speculative suggestions play a role. However, it seems likely given the discussion elsewhere in this thesis that mechanistic approaches to science education are likely to foster curricula that engage with this element, and with the element of science as creative and questioning, than other aspects of science. Paying attention to the diversity of scientific thinking and the creative dimension of science fits with a complex perspective of knowledge as dynamic and enacted in and through 'knowers' relationships with 'phenomena' (Davis and Sumara, 2006).

A complexity thinking approach to both science education and Opening Minds, then, engages with uncertainty and emergence alongside other, more mechanistic ways of

knowing and acting. I suggest that this could support the interaction and relationship between subject-based science and cross-curricular 'learning to learn' approaches like OM. Although at the stage of data collection, the relationship between science and OM was problematic as teachers were finding it challenging to develop science in the context of OM, with apparent resentments and a shifting curriculum trajectory within the network of relational power, agency and identities, this discussion engages with these problems from a complexity perspective and is able to offer some possible practical suggestions. Taking Biesta's concept of a pedagogy of interruption into the interaction between science and OM, it appears that in this case study the findings capture a process of interruption between the two. OM 'interrupts' the science curriculum that was well-established in the school, confronting science teachers with different approaches and problems. At the same time, through engaging with science teaching that was 'outside their comfort zone', the OM teachers' work with the OM curriculum and their identities as teachers was interrupted, as they worked to try to manage the challenge of the CASE lessons in the context of OM. I suggest that the complexity thinking approach to education discussed in this chapter would enable both groups of teachers to engage with the interaction between science and OM in productive ways for themselves and their students. By adopting a pedagogical approach that is responsive to both mechanistic and emergent ways of working within the educational relationship using a complex understanding of agency and reflexivity, these teachers may be able to engage with the creativity and diversity of science in productive ways that tie more closely with more recent conceptualisations of science than the 'Newtonian' approaches that still dominate school science.

7.5 Summary

In the preceding discussion, I have explored the findings using the complexity thinking approach developed in the early sections of this work to develop a 'both/and' view of interwoven mechanistic and emergent approaches to education within Biesta's 'pedagogy of interruption'. Drawing on the findings of the case in the context of tensions between freedom and facilitation of student agency on the one hand and class management and objective-based learning on the other, I considered how the multi-dimensional temporal-relational concept of agency developed in chapter 3 might work within a pedagogy of interruption to support teachers in engaging productively with these tensions. Using the

concept of reflection in the Opening Minds curriculum, I considered a number of different aspects of reflection and highlighted how a complexity-informed approach to reflection could contribute to teachers' engagement with the mechanistic and emergent aspects of their work within educational relationships. I also highlighted how reflection-as-assessment understood within such a complexity approach could offer alternative ways to manage assessment within learning-to-learn frameworks such as OM, that are not easily assessed by traditional means. Finally, I used this dynamic, alongside a complexity theoretical perspective on interdisciplinarity, to consider the interactions between science and opening minds. Here, I related the problems found in the case to issues in the science education literature and discussed the potential for complexity thinking to support both science and OM (or other L2L teachers) in engaging with each other. Threaded throughout this discussion is the idea that both mechanistic and emergent aspects of work within educational systems are part of an approach that I called 'contingently responsive and creative' and linked to a complexity reading of the notion of a pedagogy of interruption.

This discussion has only been able to address particular aspects of the findings, and I see this as an initial exploration of the 'space of the possible'. In the following, final chapter of the thesis, I offer brief discussion of how I see this work as having expanded the space of the possible in particular ways, thus making a contribution to knowledge. I also explore the limitations of the work and ways I intend to continue my explorations in future.

Chapter 8 - Summary

8.1 Introduction

I began this thesis with an introduction to the 'initial space of the possible', where I outlined the fields of educational policy, practice and research which formed the starting points for the research. Viewing the thesis as an exploration of a particular period of curriculum change using 'complexity thinking', I have attempted in this work to 'enlarge the space of the possible' in the context of teachers' negotiation of the introduction of a flexible 'learning to learn' curriculum. In this chapter, I offer a summary of the thesis and look ahead to possible future exploration. This is 'not a conclusion' (Gough, 2012 p. 53) as I do not provide closure in the sense of offering answers to clearly formulated research questions. I do, however, discuss where a contribution to knowledge has been made – where the 'space of the possible' has been expanded in particular ways – and explore the implications of this research for classroom practice and future research. I also discuss the strengths and limitations of the research and the particular methodological approaches taken.

8.2 Summary and implications

In this thesis, I have explored a case study of curriculum change using complexity theory to frame the research because it offers an alternative perspective to the 'mechanistic' view of education that continues to dominate much research and practice. The research was undertaken in a context of change to the National Curriculum which introduced greater flexibility for schools and emphasised the importance of 'personal, learning and thinking skills' (QCA, 2007a). In the case study, these changes enabled the introduction of an 'Opening Minds' curriculum which, I argued, has the *potential* to challenge the dominance of outcomes-based, mechanistic approaches to education. Although limited to the particular setting and individuals involved in the case study, the research findings explore the tensions experienced by teachers in this case in relation to the introduction of this kind of curriculum. This research brings these empirical findings into dialogue with the complexity theoretical perspective and in doing so, makes a distinctive contribution to knowledge in various ways.

In the first section of the thesis, I outlined the research context and then drew on the literature in complexity theory and education to introduce three key concepts in the complexity theoretical framework; relational and temporal dimensions of emergence and complexity reduction, building in particular on the 'logic of strong emergence' (Osberg and

Biesta, 2007). I then used these concepts to develop temporal-relational conceptualisations of agency, identity, power and reflexivity. In doing so, I built on existing social theory in combination with complexity thinking to redevelop these concepts in 'complex' ways. In exploring Emirbayer and Mische's (1998) discussion of agency as a multi-dimensional temporal-relational construct, I argued that a creative dimension to agency is as important as a projective dimension within the unpredictable and indeterminate future that is part of the nature of complex systems. I then adapted this argument in relation to identity, power and reflexivity to highlight that within a complexity framework, relationality, situated with the flow of time, is the foundation on which emergence of structure, agency and identity continue, influenced by a pervasive network of power relations and continued process of reflexivity that can act in emergent or mechanistic ways. Although these ideas are not new of themselves, I suggest that bringing these concepts together in these ways, within the framework of complexity, offers an original contribution to the field of complexity theory in education.

Having developed my complexity theoretical framework and its relationship to key ideas in social theory, I have used these ideas to explore a case study of curriculum change. The findings in this case illustrated various ways in which the teachers who were working with the Opening Minds curriculum at Bridge Community School experienced and negotiated tensions between mechanistic and emergent ways of engaging with their pupils, with the curriculum, and with each other, resulting in a unique curriculum trajectory. Although the findings discussed are limited to this case with these participants, I explored the findings through a complexity theoretical lens, which enabled me to further develop the theoretical concepts and their practical implications. In bringing the empirical work together with the earlier theoretical work in the thesis and the existing work in the field, I was able to develop some new insights which I believe will be of interest to researchers in the field and of benefit to practitioners.

The first of these insights is in the relationship between mechanistic and emergent approaches to education. The findings in this case study show that teachers used Opening Minds to attempt to work in innovative and flexible ways, but that they also continued to use mechanistic, ends-based ways of working that fail to take account of the unpredictability of complex systems. I argued that rather than seeing these two aspects in

opposition, they could be viewed as a form of 'vital simultaneity' (Davis, 2008) which interweave within complex educational relationships. I used the concept of creative agency highlighted earlier to explore how such an interaction between mechanistic and emergent approaches might be facilitated within what Biesta calls a 'pedagogy of interruption' (Biesta, 2006). In this way, my empirical work has enabled further insight into how Biesta's theorisation of a pedagogy of interruption might work in practice. I have also shown how such an interwoven approach to mechanistic and emergent elements in teachers' work might support teachers engaging with unpredictable and messy classroom practices that are perhaps more likely to be fostered during a curriculum change towards 'learning to learn' (L2L), where 'learning outcomes' are difficult to define and assess.

The problem of assessment within L2L was highlighted in the introduction to the study, and my research showed how the teachers in this case engaged with this problem through use of 'reflection' within Opening Minds. I explored the data using four different aspects of reflection – reflection-as-process, reflection-as-interaction, reflection-as-assessment, and reflection-as-action. In discussing these findings in the context of complexity, I argued that reflection could be used in responsive and flexible ways to support both learning and assessment as a crucial aspect of a pedagogy of interruption. Having previously related reflexivity to emergence and complexity reduction in the context of creative and projective agency, I applied this to the findings to consider how reflection in this case related to this concept of reflexivity. This enabled me to develop a notion of 'Reflection-for-Learning' – in contrast with Assessment for Learning – that could enable teachers to weave reflection as a form of assessment together with reflection that enables emergence, by reflecting on the past in ways that experiment with it to invent something new and unexpected.

The final part of the case study explored my interest in the relationship between the new 'Learning to Learn' aspects of the curriculum and science education as my area of specialism. In this case study, I found that these areas were clearly in tension and that negotiation of these tensions was proving particularly problematic for the teachers. This was in some ways surprising to me, because I see the questioning and experimental aspects of the new curriculum as tying together with the creative and questioning aspects that are part of the nature of science. Drawing on insights from complexity theory for interdisciplinary work, I explored the tensions between science and OM in this case using the concept of the

'embodied history' of complex systems that form part of the teachers' identity enacted in their relationships in the case. The findings in this case mirror those in the science education literature, that science in school pays less attention to aspects of science that could be seen as more 'complex' or 'emergent' (such as questioning, creativity and diversity of thinking) and more attention to the 'mechanistic' (such as scientific method, content and techniques). This combined with the perception on the part of the OM teachers that science is prescriptive and difficult to create a situation in which natural similarities between the two aspects were untapped. Reading these findings with a complexity lens, I suggested that a complexity approach might enable teachers working in similar contexts to engage with both mechanistic and emergent approaches of *both* science *and* Opening Minds in ways that could support the interaction between them productively. In the context of science, a complex approach to a pedagogy of interruption such as that outlined in this thesis would support teachers in engaging with the creative and diverse elements of science (such as that found in inquiry-based science education) whilst maintaining the mechanistic aspects of teaching that support students in learning key concepts and skills in science. I discussed this kind of pedagogy in terms of a 'contingently responsive and creative' approach to teaching (Wegerif et al., In preparation for 2012/13) that is *also* important within a 'learning to learn' style of curriculum like Opening Minds.

The preceding summary of the thesis shows the contribution to knowledge in relation to the field of complexity theory and education via a particular development of Biesta's pedagogy of interruption that incorporates both mechanistic and emergent elements. I suggested that these elements could be negotiated by teachers within such a pedagogy through a formulation of agency that includes a creative dimension and through the use of reflection. The importance of this for teachers is that it foregrounds the unpredictability of their work and enables them to explicitly develop this unpredictability as part of their pedagogical practice. I showed how this kind of approach might work in the context of assessment within the learning process and in the context of science education in relation to 'learning to learn'.

8.3 Reflection on methodology and design

Alongside the theoretical and empirical work, in this thesis I included an exploration of a complexity-informed methodology. I believe one of the strengths of this research is in the

explicit use of the complexity theoretical lens to inform the methodological decision-making, taking seriously insights from complexity in 'designing' the research with the concomitant challenges of the complexity reduction that must result. The case study design, combined with the bricolage approach, made a carefully justified attempt to remain open to emergence within the research whilst maintaining a thoughtful and ethical stance. However, the research is limited in its scope and potential and I would like to discuss some of the limitations that became clear to me during the research, reflecting on the question, 'what would I do differently'? Such a reflection is necessary from a complexity theoretical perspective, as a recursive, iterative and creative process of reflection as part of the research process can potentially inform both my own and others' future research. Firstly, the research was limited in time and in access. Had more time been available, the findings could have been further enriched through multiple interviews with the participants (both teachers and students) throughout the period of design and implementation of the Opening Minds curriculum, as this would have enabled me to explore how their ideas were changing during the research, which would have been interesting to explore in relation to the notions of iterative, practical-evaluative, projective and creative agency. This would also have enabled me to build relationships with the student participants in the project, who were relatively reticent in their interviews with me, making this the least rich aspect of the data on which I drew for this work. I would also have valued a more complete sample to enrich the case study, as one OM teacher and a few Science teachers were unable to participate in interviews due to constraints on their time.

There were also limitations in my work with the data which arose due the part-time nature of the PhD which prevented me from engaging in data collection at particular times and which also prevented me from always analysing the data as quickly as I would have hoped in order to inform further data collection. I remedied this as best I could by audio-recording data and research journal entries which I transferred to CD to listen to in my car, but this remained an ad hoc way to engage with the data at busy times.

A second area where there were clear limitations of the study is in the emphasis of the data collection on individual interviews and written lesson observations. These allowed me some insights into the relationships within the case, but having conducted the study using these standard qualitative data collection techniques, I feel that the focus on relationships that is

an important part of a complex perspective could have been further facilitated through other forms of data collection, in particular through the use of video. Video has been used within social research for many years, but is a challenging tool to use due to the 'extraordinary detail' and complexity of the data collected (Heath et al., 2010). However, I feel that video would provide insight into educational relationships within class in ways that researcher-observation cannot, as it would enable more detailed analysis of group interactions, and teacher interactions with individuals and groups of students, in ways that are not feasible within a straightforward lesson observation. The lack of information in my case study about networked interactions within class and the ways different relationships were acted out in class is a gap in the data in this case. It would therefore be interesting to explore the use of video in further study of classroom interactions, to explore the temporal-relational concepts developed in this study in practice in greater depth. Video would also facilitate research into the interaction between the human systems in the research and the material, a further aspect which I have highlighted in the theoretical work in this thesis as important within complexity, but into which the data in this case study affords little insight. Recent work in the field of material feminism, particularly the work of Karen Barad (Barad, 2007, Youngblood Jackson and Mazzei, 2012), would be interesting to explore further in relation to this aspect of complexity-informed research and methodology but was not taken up in this research. A further limitation in relation to the methodology employed is in my lack of engagement with the work of Deleuze and Guattari. This has been used by a number of complexity theorists and others working in the fields of poststructural and feminist research in education (Semetsky, 2006, Gough, 2006, Mazzei and McCoy, 2010), with Deleuze's concepts of 'rhizomes' and 'lines of flight' being related to the concept of emergence so important within a complexity framework. I deliberately took the decision, in consultation with my supervisors, to limit my methodological bricolage in this way because of the pressures of time, but given that this is an aspect of methodological literature in complexity and education, this decision has consequences for the relationship of this thesis to the wider literature and therefore merits mention here.

Finally, although I have argued that the case study approach is appropriate from the perspective of complexity thinking, as generalisation across unique complex systems is impossible, it remains the case that this study uses the findings of one case to develop

theoretical concepts and practical implications that *may* be beneficial, but that can only ever be suggestions for further experimentation with the space of the possible. It is unable to offer any certainties that engagement with the suggestions and ideas reported here will enable particular outcomes. Whether this is a limitation or not rather depends on the reader's point of view. From the point of view of complexity thinking, such certainty is never possible, and it is the potential for exploration and the emergence of new insights and new learning that is important.

In the context of what I might do differently, then, the above reflections on the limitations of the methodological approach to the study focus on a pattern of a lack of potential in the methodological design for documenting and exploring the complex learning system that is the 'Opening Minds System' as an evolving, emerging phenomenon that gradually developed a coherent identity. My research, with its focus on collecting data predominantly from the perspective of individuals, meant that it was difficult to explore in a systematic way the interactions in the system that contributed to its emergence and development, as well as the learning taking place within that system at levels beyond the individual perspectives. Although I used a number of tools to attempt to explore and represent the system, including word clouds and graphs of group responses, the way that these were used meant that they provided snapshots with limited insight into change over time. In conducting a similar, complexity informed study of a changing complex school system in future, I would therefore advocate a number of possible methods to complement those used in this study in order to address the limitations identified here.

Alongside the use of video to facilitate mapping of classroom interactions and learning, and team interactions in the development of Opening Minds, a study of a school system such as this could benefit from finding ways to study the learning and dynamic interactions of groups such as classes, teaching teams or year groups, as (in this case) the new curriculum develops. In this study, representation of data from groups was limited to data collected individually through questionnaires and analysed to represent the thinking of classes or year groups. Further insight could potentially be gained through techniques such as groups working to develop their ideas using online social media such as 'wikis', or group representation and discussion of word clouds (Loveless and Griffith, 2012), or group concept mapping of developing ideas, using techniques such as those currently being developed to

explore thinking in science and maths (e.g. <http://www.metafora-project.org/>). Such techniques, designed to enable insight into the learning and emergence of the system at different levels of complexity, would need to be used within a more structured longitudinal design than the one employed in this project, where there were few opportunities to repeatedly interview many participants. If it were feasible to implement such methods as part of a bricolage methodological approach such as that employed in this study, it could complement the insights available from interview, observation and questionnaire data, and enable greater breadth and depth of exploration of the internal shapes and interactions at different levels of the complex system, as well as exploring the system over the range of timescales in which change occurs.

The complexity theoretical framework offered in this thesis discusses a conceptualisation of reflection in the context of emergence and mechanistic change that considers that act of reflection as potentially both mechanistic and emergent, with both iterative (outcomes oriented) and creative dimensions. By reflecting on the way in which the research for this study was conducted to identify strengths and limitations from the complexity theoretical framework in which this work is situated, I offer an iterative analysis of how this research, or similar future research, might be improved. Alongside this, I also hope that these reflections, when brought into dialogue with new contexts and ideas, might enable creative future approaches to conducting complexity-informed research.

8.4 Thoughts about further exploration

I end this thesis with some thoughts about areas of further exploration in relation to complexity and education in general and the topics of this case study in particular. In relation to the case study, there are aspects of the data that I have not been able to include in the discussion in this thesis for reasons of time and space. In particular, the interactions in the case in relation to the concept of students' 'ability' was an interesting element of the data that I was not able to highlight in the findings and discussion, and this will merit further work to develop these findings in light of the theoretical concepts discussed in the thesis. Informed by the case study, the ideas briefly discussed in the context of how a pedagogy of interruption might be used within inquiry based science education could be taken up in further research. Again, in the context of science, the interactions between the material and the human learning systems in the class from a complexity perspective could be an

interesting area to explore in relation to practical work in science education. Practical work remains a highly valued aspect of science education in the UK, and how the practical element of science relates to the pedagogy of interruption discussed here from a complexity lens is a potentially rich area to explore. Methodologically, the use of video to research complex classroom relationships, as highlighted above, would be an interesting dimension to such research. Similarly, the concept of reflection and its role within 'complex' classroom practice would merit further research in light of this work. This could potentially be facilitated within a 'learning to learn' curriculum, building on the current work, but would be equally interesting to take in to other aspects of education in relation to subject-based learning in secondary schools or in relation to reflexive practice in teacher education.

In summary, this thesis makes a contribution in the small but growing field of complexity and education and is one of a relatively small number of studies that uses complexity theory as the guiding framework for empirical research. As such, it contributes to the field in terms of theory and methodology as well as in relation to the empirical findings. 'Complex methodology' in empirical work remains a relatively underdeveloped area of the complexity and education literature and is also a potential area for further work that could build on this thesis as part of the wider field. My hope is that the thesis and the topics it explores will enable me to spark further exploration in the area of complexity, particularly in relation to science education. It is my hope that whoever else interacts with published work drawn from this thesis also engages in new ways, with new ideas, insights and possibilities emerging as a result in ways that I cannot anticipate.

List of References

- AAAS (1989) Science for all Americans: a Project 2061 report on literacy goals in science, mathematics and technology. Washington, DC, AAAS.
- ADEY, P. (1999) The Science of Thinking, and Science for Thinking: A Description of Cognitive Acceleration through Science Education (CASE). . *Innodata Monographs*, 2.
- ADEY, P., SHAYER, M. & YATES, C. (2003) *Thinking Science*, London, Nelson Thornes.
- ALHADEFF-JONES, M. (2008) Three generations of complexity theories: nuances and ambiguities. *Educational Philosophy and Theory*, 40, 66-82.
- ALHADEFF-JONES, M. (2009) Revisiting Educational Research Through Morin's Paradigm of Complexity. *Complicity: An International Journal of Complexity & Education*, 6, 61-70.
- ARCHER, M. (2003) *Structure, Agency and the Internal Conversation*, Cambridge, Cambridge University Press.
- ASSESSMENT REFORM GROUP (1999) Assessment for Learning: Beyond the Black Box. Cambridge, University of Cambridge School of Education.
- BALL, S., J. (2011) Foreword. IN SOMEKH, B. & LEWIN, C. (Eds.) *Theory and Methods in Social Research*. Second Edition ed. London, SAGE.
- BARAD, K. (2007) *Meeting the Universe Halfway: Quantum Physics And the Entanglement of Matter And Meaning*, Durham, NC, Duke University Press.
- BARBER, M. (2001) Reflections on Progress towards a World Class Education System. *Cambridge Journal of Education*, 29, 183-193.
- BARNES, B. (1996) Sociological theories of scientific knowledge. IN OLBY, R. C., CANTOR, G. N., CHRISTIE, J. R. R. & HODGE, M. J. S. (Eds.) *Companion to the History of Modern Science*. London, Routledge.
- BAUMAN, Z. (1993) *Postmodern Ethics*, Oxford, Blackwell.
- BEDAU, M. A. & HUMPHREYS, P. (Eds.) (2008) *Emergence: Contemporary Readings in Philosophy and Science*, Boston, MIT Press.
- BERA (2004) Revised Ethical Guidelines for Educational Research. Southall, BERA.
- BESWICK, K., WATSON, A. & DE GEEST, E. (2007) Describing Mathematics Departments: The Strengths and Limitations of Complexity Theory and Activity Theory. IN WATSON, J. & BESWICK, K. (Eds.) *Mathematics: essential research, essential practice: 30th Annual Conference of the Mathematics Education Research Group of Australasia*. University of Tasmania, MERGA.
- BIESTA, G. (2004) "Mind the gap!" Communication and the educational relation. . IN BINGHAM, C. & SIDORKIN, A. M. (Eds.) *No Education Without Relation*. New York, Peter Lang.
- BIESTA, G. (2005) Against Learning. Reclaiming a language for education in an age of learning. *Nordisk Pedagogik*, 25, 54-66.
- BIESTA, G. (2006) *Beyond Learning*, Boulder, CO, Paradigm.
- BIESTA, G. (2007) Why 'What Works' Won't Work: Evidence-based Practice and the Democratic Deficit in Educational Research. *Educational Theory*, 57, 1-22.
- BIESTA, G. (2009a) Good education in an age of measurement: on the need to reconnect with the question of purpose in education. *Educational Assessment, Evaluation & Accountability*, 21, 33-46.
- BIESTA, G. (2009b) Theorizing Learning through Complexity: An Educational Critique. *Complicity: An International Journal of Complexity & Education*, 6, 28-33.

- BIESTA, G. (2010a) Five Theses on Complexity Reduction and its Politics. IN OSBERG, D. & BIESTA, G. (Eds.) *Complexity Theory and the Politics of Education*. Rotterdam, Sense.
- BIESTA, G. & OSBERG, D. (2007) Beyond Re/Presentation: A Case for Updating the Epistemology of Schooling. *Interchange*, 38, 15-29.
- BIESTA, G. & TEDDER, M. (2007) Agency and learning in the lifecourse: Towards an ecological perspective. *Studies in the Education of Adults*, 39, 132-149.
- BIESTA, G. J. J. (2010b) Why 'What Works' Still Won't Work: From Evidence-Based Education to Value-Based Education. *Studies in Philosophy & Education*, 29, 491-503.
- BLACK, P. (1995) 1987 to 1995 - the struggle to formulate a national curriculum for science in England and Wales. *Studies in Science Education*, 26, 159-188.
- BLACK, P., MCCORMICK, R., JAMES, M. & PEDDER, D. (2006) Learning How to Learn and Assessment for Learning: a theoretical inquiry. *Research Papers in Education*, 21, 119-132.
- BLACK, P. & WILLIAM, D. (2010) Inside the Black Box: Raising Standards Through Classroom Assessment. *Phi Delta Kappan*, 92, 81-90.
- BLACKMAN, P. (2008) A New Science Look at Negotiating Curriculum and Classrooms. *Complicity: An International Journal of Complexity & Education*, 5, 141-148.
- BLEAKLEY, A. (1999) From Reflective Practice to Holistic Reflexivity. *Studies in Higher Education*, 24, 315.
- BLOOM, J. W. & VOLK, T. (2007) The Use of Metapatterns for Research into Complex Systems of Teaching, Learning, and Schooling. Part II: Applications *Complicity: An International Journal of Complexity & Education*, 4, 45-68.
- BOGG, J. & GEYER, R. (2007) Introduction. IN BOGG, J. & GEYER, R. (Eds.) *Complexity Science & Society*. Oxford, Radcliffe Publishing Ltd.
- BOURDIEU, P. (1977) *Outline of a Theory of Practice*, Cambridge, Cambridge University Press.
- BOYATZIS, R. (1998) *Transforming Qualitative Information: Thematic Analysis and Code Development*, Thousand Oaks, CA, SAGE.
- BURDEN, R. L. & NICHOLS, S. L. (2000) Evaluating the process of introducing a thinking skills programme into the secondary school curriculum. *Research Papers in Education*, 15, 293-306.
- BURGESS, R. G. (Ed.) (1984) *The Research Process in Educational Settings: Ten Case Studies*, Lewes, The Falmer Press.
- BYRNE, D. (1998) *Complexity Theory and the Social Sciences*, London, Routledge.
- BYRNE, D. (2005) Complexity, Configurations and Cases. *Theory, Culture & Society*, 22, 95-111.
- BYRNE, D. (2007) Qualitative Complexity: Ecology, Cognitive Processes and the Re-emergence of Structures in Post-Humanist Social Theory - By J. Smith and C. Jenks. *British Journal of Sociology*, 58, 337-338.
- CAHOONE, L. E. (Ed.) (2003) *From Modernism to Postmodernism: An Anthology*, Oxford, Blackwell.
- CAPRA, F. (1996) *The Web of Life*, London, HarperCollins.
- CARR, D. (2007) TOWARDS AN EDUCATIONALLY MEANINGFUL CURRICULUM: EPISTEMIC HOLISM AND KNOWLEDGE INTEGRATION REVISITED. *British Journal of Educational Studies*, 55, 3-20.
- CHADDERTON, C. & TORRANCE, H. (2011) Case Study. IN SOMEKH, B. & LEWIN, C. (Eds.) *Theory and Methods in Social Research*. London, SAGE.

- CHARMAZ, K. (2006) *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*, London, SAGE.
- CICCONE, A. A., MEYERS, R. A. & WALDMANN, S. (2008) What's So Funny? Moving Students Toward Complex Thinking in a Course on Comedy and Laughter. *Arts & Humanities in Higher Education*, 7, 308-322.
- CILLIERS, P. (1998) *Complexity and Postmodernism: Understanding Complex Systems*, New York, Routledge.
- CILLIERS, P. (2005) Complexity, deconstruction and relativism. *Theory, Culture & Society*, 22, 255-267.
- CLARKE, A. E. (2005) *Situational Analysis*. SAGE.
- CLAXTON, G. (2002) *Building Learning Power: Helping young people become better learners*, Bristol, TLO.
- CLAXTON, G. (2006) Thinking at the edge: developing soft creativity. *Cambridge Journal of Education*, 36, 351-362.
- COHEN, L., MANION, L. & MORRISON, K. (2006) *Research Methods in Education: A Routledge Companion Website*. Taylor and Francis Group.
- COHEN, L., MANION, L. & MORRISON, K. (2007) *Research Methods in Education*, London and New York, RoutledgeFalmer.
- COMMISSION, E. (2004) *Europe needs More Scientists: Report by the High Level Group on Increasing Human Resources for Science and Technology*. Brussels, European Commission.
- CONNELLY, M. F. (Ed.) (2008) *The Sage Handbook of Curriculum and Instruction*, Thousand Oaks, CA, Sage.
- COOLE, D. & FROST, S. (2010) *New Materialisms: Ontology, Agency, and Politics*, Duke University Press.
- COOPER, H., BRAYE, S. & GEYER, R. (2004) Complexity and interprofessional education. *Learning in Health & Social Care*, 3, 179-189.
- CRABTREE, B. & MILLER, W. (1999) A Template Approach to Text Analysis: Developing and Using Codebooks. IN CRABTREE, B. & MILLER, W. (Eds.) *Doing Qualitative Research*. Newbury Park, CA, SAGE.
- DAVID, G. E. (2001) A Complexity Theory Analysis of Educational Reform in Benin.
- DAVIS, B. (2008) Complexity and education: vital simultaneities. *Educational Philosophy and Theory*, 40, 50-65.
- DAVIS, B. & PHELPS, R. (2004) Complicity: An introduction and welcome. *Complicity: An International Journal of Complexity & Education*, 1, 1-7.
- DAVIS, B. & PHELPS, R. (2005) Exploring the Common Spaces of Education and Complexity: Transphenomenality, Transdisciplinarity, and Interdiscursivity. *Complicity: An International Journal of Complexity & Education*, 2, 1-4.
- DAVIS, B. & PHELPS, R. (2007) Editorial. *Complicity: An International Journal of Complexity and Education*, 4, 1-4.
- DAVIS, B. & SIMMT, E. (2003) Understanding learning systems: Mathematics education and complexity science. *Journal for Research in Mathematics Education*, 34, 137-167.
- DAVIS, B. & SUMARA, D. (2006) *Complexity and Education: Inquiries into Teaching, Learning and Research*, Mahwah, NJ, Lawrence Erlbaum Associates.
- DAVIS, B. & SUMARA, D. (2007) Complexity Science and Education: Reconceptualizing the Teacher's Role in Learning. *Interchange*, 38, 53-67.

- DAVIS, B., SUMARA, D. & LUCE-KAPLER, R. (2000) *Engaging Minds: Learning and Teaching in a Complex World*, Mahwah, NJ, Lawrence Erlbaum Associates.
- DAVIS, B., SUMARA, D. & LUCE-KAPLER, R. (2007) *Engaging Minds: Learning and Teaching in a Complex World* Mahwah, NJ, Lawrence Erlbaum Associates.
- DAVIS, B. & SUMARA, D. J. (1997) Cognition, Complexity, and Teacher Education. *Harvard Educational Review*.
- DAVIS, B. & SUMARA, D. J. (2005) Challenging Images of Knowing: Complexity Science and Educational Research. *International Journal of Qualitative Studies in Education*, 18, 305-321.
- DAVIS, B. & SUMARA, D. J. (2012) Fitting Teacher Education in/to/for an Increasingly Complex World. *Complicity: An International Journal of Complexity & Education*, 9, 30-40.
- DCFS (2009) Curriculum Provision in Secondary Science. DCFS.
- DE BONO, E. (2000) *Six Thinking Hats*, London, Penguin.
- DEARING, R. (1997) Summary Report of the National Committee of Inquiry into Higher Education.
- DEMOS (2005) About Learning. London, DEMOS.
- DENZIN, N. K. & LINCOLN, Y. S. (2000) *Handbook of Qualitative Research*, Thousand Oaks, CA, Sage.
- DFE (1997-2010) The National Strategies. The National Archives.
- DFE (2011) Curriculum Aims Values, Purposes: Purposes. Department for Education.
- DFES (2005) 14-19 Education and Skills White Paper. IN DFES (Ed.), TSO.
- DODD, H. & SHAW, K. (1990) Science in the curriculum of the eighties. *British Journal of Educational Studies*, 38, 33-46.
- DOLL, J., WILLIAM E. & GOUGH, N. (Eds.) (2002) *Curriculum Visions*, New York, Peter Lang.
- DOLL JR, W. E. (1993a) Curriculum possibilities in a 'post'-future. *Journal of Curriculum & Supervision*, 8, 277-292.
- DOLL JR, W. E. (1993b) *A Postmodern Perspective on Curriculum*, New York, Teachers College Press.
- DOLL JR, W. E. (2008) "Maturana Is Not a Constructivist" ... Nor Is Piaget. *Complicity: An International Journal of Complexity & Education*, 5, 27-31.
- DOLL, W. E., JR. (1986) Prigogine: A New Sense of Order, A New Curriculum. *Theory into Practice*, 25, 10-16.
- DONNELLY, J. (2001) Contested terrain or unified project: 'The nature of science' in the National Curriculum for England and Wales. *International Journal of Science Education*, 23, 181-195.
- DONNELLY, J., BUCHAN, A., JENKINS, E. W., LAWS, P. & WELFORD, G. (1996) *Investigations by order*, Driffield, Studies in Education.
- DONNELLY, J. F. (2006) The intellectual positioning of science in the curriculum, and its relationship to reform. *Journal of Curriculum Studies*, 38, 623-640.
- DUPRE, J. (2003) *Human Nature and the Limits of Science*. , Oxford, Oxford University Press.
- EDWARDS, R. (2012) Lifelong Learning: A Post-human Condition? IN ASPIN, D. N., CHAPMAN, J., EVANS, K. & BAGNALL, R. (Eds.) *Second International Handbook of Lifelong learning*. Springer.
- ELLIOTT, A. & DU GAY, P. (Eds.) (2009) *Identity in Question*, London, SAGE.

- ELLIS, A., HASE, S. & PHELPS, R. (2005) Competency, capability, complexity and computers: exploring a new model for conceptualising end-user computer education. *British Journal of Educational Technology*, 36, 67-84.
- EMIRBAYER, M. & MISCHKE, A. (1998) What is Agency? *American Journal of Sociology*, 103, 962-1023.
- ENGESTROM, Y., MIETTINEN, R. & PUNAMAKI, R.-L. (Eds.) (1999) *Perspectives on Activity Theory*, Cambridge, Cambridge University Press.
- EVANS, L. (2002) *Reflective Practice in Educational Research: Developing Advanced Skills*, London; New York, Continuum.
- FENWICK, T. (2003) Reclaiming and re-embodying experiential learning through complexity science. *Studies in the Education of Adults*, 35, 123-141.
- FENWICK, T. (2009a) Responsibility, Complexity Science and Education: Dilemmas and Uncertain Responses. *Studies in Philosophy and Education*, 28, 101-118.
- FENWICK, T. (2009b) Responsibility, Complexity Science and Education: Dilemmas and Uncertain Responses. *Studies in Philosophy & Education*, 28, 101-118.
- FENWICK, T. (2010a) Complexity Theory, Leadership, and the Traps of Utopia. *Complicity: An International Journal of Complexity & Education*, 7, 90-96.
- FENWICK, T. (2010b) Normalising Standards in Educational Complexity: A Network Analysis. IN OSBERG, D. & BIESTA, G. (Eds.) *Complexity Theory and the Politics of Education*. Rotterdam, Sense.
- FENWICK, T. (2010c) Rethinking the 'thing': Sociomaterial approaches to understanding learning in work. *Journal of Workplace Learning*, 22, 104-116.
- FENWICK, T. & EDWARDS, R. (2010) *Actor-Network Theory in Education*, London, Routledge.
- FENWICK, T. J. (2004) The Practice-Based Learning of Educators: A Co-Emergent Perspective. *Scholar-Practitioner Quarterly*, 2, 43-59.
- FEREDAY, J. & MUIR-COCHRANE, E. (2006) Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*, 5, 80-92.
- FINKELSTEIN, A., HETHERINGTON, J., LI, L., MARGONINSKI, O., SAFFREY, P., SEYMOUR, R. & WARNER, A. (2004) Computational Challenges of Systems Biology. *IEEE Computer*, 37, 26-33.
- FLEENER, M. J. (2002) Logical Foundations for an Organocentric Curriculum: Dewey's Logic and Complexity Sciences. IN DOLL, W. E. J. & GOUGH, N. (Eds.) *Curriculum Visions*. New York, Peter Lang.
- FRELIN, A. & GRANNAS, J. (2010) Negotiations left behind: in-between spaces of teacher-student negotiation and their significance for education. *Journal of Curriculum Studies*, 42, 353-369.
- FUCHS, S. (2001) Beyond Agency. *Sociological Theory*, 19, 24-40.
- FULLAN, M. (1993) *Change Forces: Probing the Depths of Educational Reform*, London, The Falmer Press.
- FULLAN, M. (2003) *Change Forces with a Vengeance*, London, RoutledgeFalmer.
- GARDNER, H. (1983, 2004) *Frames of Mind: Theory of Multiple Intelligences*, New York, Basic Books.
- GBRICH, C. (2007) *Qualitative Data Analysis: An Introduction*, London, SAGE.
- GEELAN, D. R. (1997) Epistemological Anarchy and the Many Forms of Constructivism. *Science and Education*, 6, 15-28.

- GERSHON, W. S. (2008) Intent and Expression: Complexity, Ethnography and Lines of Power in Classrooms. *Journal of the Canadian Association for Curriculum Studies*, 6, 45-71.
- GIBBS, G. (2011) Online Qualitative Data Analysis: Writing As Analysis. University of Huddersfield, School of Human and Health Sciences.
- GIDDENS, A. (1979) *Central Problems in Social Theory*, Basingstoke, Macmillan.
- GIDDENS, A. (1984) *The constitution of society: outline of the theory of structuration*, Cambridge, Polity Press.
- GILLARD, D. (2011) Education in England: A brief history.
- GLENNERSTER, H. (2001) United Kingdom Education 1997-2001. London, Centre for Analysis of Social Exclusion, London School of Economics.
- GOTT, R. & DUGGAN, S. (1995) *Investigative work in the science curriculum*, Buckingham, Open University Press.
- GOUGH, N. (2006) Shaking the Tree, Making a Rhizome: Towards a nomadic geophilosophy of science education. *Educational Philosophy & Theory*, 38, 625-645.
- GOUGH, N. (2009) No Country for Young People? Anxieties in Australian Society and Education. *Australian Educational Researcher*, 36, 1-19.
- GOUGH, N. (2010) Can We Escape the Program? Inventing Possible~Impossible Futures in/for Australian Educational Research. *Australian Educational Researcher*, 37, 9-42.
- GOUGH, N. (2012) Complexity, Complexity Reduction, and 'Methodological Borrowing' in Educational Inquiry. *Complicity: An International Journal of Complexity & Education*, 9, 41-56.
- GOULART, M. I. M. & ROTH, W.-M. (2010) Engaging Young Children in Collective Curriculum Design. *Cultural Studies in Science Education*, 5, 533-562.
- GOVE, M. (2011) Michael Gove Speech to the Durand Academy, 1st September 2011.
- GRIFFITHS, H. (2009) New School Geographies: Engaging Young People? *Geography*. Exeter, University of Exeter.
- GUBA, E. G. & LINCOLN, Y. S. (1994) Competing Paradigms in Qualitative Research. IN DENZIN, N. K. & LINCOLN, Y. S. (Eds.) *Handbook of Qualitative Research*. London, Thousand Oaks.
- HACKER, R. G. & ROWE, M. J. (1998) A longitudinal study of the effects of implementing a National Curriculum project upon classroom processes. *Curriculum Journal*, 9, 95-103.
- HAGGIS, T. (2004) Meaning, identity and 'motivation': expanding what matters in understanding learning in higher education? *Studies in Higher Education*, 29, 335-352.
- HAGGIS, T. (2007) Conceptualising the case in adult and higher-education research: a dynamic systems view. IN BOGG, J. & GEYER, R. (Eds.) *Complexity, Science and Society*. Oxford, Radcliffe.
- HAGGIS, T. (2008) Knowledge must be contextual: some possible implications of complexity and dynamic systems theories for educational research. *Educational Philosophy and Theory*, 40, 158-176.
- HAGGIS, T. (2009) Beyond 'mutual constitution': looking at learning and context from the perspective of complexity theory. IN EDWARDS, R., BIESTA, G. & THORPE, M. (Eds.) *Rethinking Contexts for Learning and Teaching: Communities, Activities and Networks*. London, Routledge.
- HALL, E., LEAT, D., WALL, K., HIGGINS, S. & EDWARDS, G. (2006) Learning to Learn: teacher research in the Zone of Proximal Development. *Teacher Development*, 10, 149-166.

- HAMMERSLEY, M. (2006) Philosophy's Contribution to Social Science Research on Education. *Journal of Philosophy of Education*, 40, 273-286.
- HAMMERSLEY, M. (Ed.) (2007) *Educational Research: Evidence-based practice*, Milton Keynes, The Open University.
- HARDING, M. (2010) Is Complexity Theory Useful in Describing Classroom Learning? *The European Conference on Educational Research*. Helsinki, Academia.edu.
- HARGREAVES, D. (1999) Revitalising educational research: Lessons from the past and proposals for the future. *Cambridge Journal of Education*, 23, 405-419.
- HEATH, C., HINDMARSH, J. & LUFF, P. (2010) *Video in Qualitative Research: Analysing Social Interaction in Everyday Life*, London, SAGE.
- HETHERINGTON, L. (2007) View of Planet Earth: Systems Thinking in Earth Science Education Pilot Study *British Educational Research Association Conference, 2007*. Institute of Education, London, Leeds Online.
- HEYLIGHEN, F., CILLIERS, P. & GERSHENSON, C. (2007) Complexity and Philosophy. IN BOGG, J. & GEYER, R. (Eds.) *Complexity Science & Society*. Oxford, Radcliffe Publishing Ltd.
- HIGGINS, S., WALL, K., BAUMFIELD, V., HALL, E., LEAT, D. & WOOLNER, P. (2006) Learning to Learn in Schools Phase 3 Evaluation Year Two Report. Newcastle-Upon-Tyne, University of Newcastle Centre for Teaching and Learning, for the Campaign for Learning.
- HILLAGE, J. (1998) Excellence in research on schools. London, DfES.
- HITCHCOCK, G. & HUGHES, D. (1995) *Research and the Teacher*, London, Routledge.
- HOLLAND, J. (1998) *Emergence*, Oxford, Oxford University Press.
- HORN, J. (2008) Human research and complexity theory. *Educational Philosophy and Theory*, 40, 130-143.
- HOSKINS, B. & FREDRIKSSON, U. (2008) Learning to Learn: What is it and can it be measured? *Joint Research Centre – Institute for the Protection and Security of the Citizen – Scientific and Technical Research series*. Luxembourg, Office for Official Publications of the European Communities.
- HUNTER, W. J. & BENSON, G. D. (1997) Arrows in time: The misapplication of chaos theory to education. *Journal of Curriculum Studies*, 29, 87-100.
- INSTITUTE, S. F.
- JACKSON, P. W. (1990) *Life in Classrooms*, New York, Teachers College Press.
- JAMES, M., BLACK, P., MCCORMICK, R., PEDDER, D. & WILIAM, D. (2006) Learning How to Learn, in Classrooms, Schools and Networks: aims, design and analysis. *Research Papers in Education*, 21, 101-118.
- JENKINS, E. & PELL, A. (2006) The Relevance of Science Education Project (ROSE) in England: a summary of findings. *International Relevance of Science Education Project*.
- KINCHELOE, J. J. (2001a) Chapter 10: What's Complex about Our Notion of Complexity? Extending the Epistemology of Complexity. *Getting Beyond the Facts: Teaching Social Studies/Social Sciences in the Twenty-first Century*. Peter Lang Publishing, Inc.
- KINCHELOE, J. J. (2001b) Describing the Bricolage: Conceptualizing a New Rigor in Qualitative Research. *Qualitative Inquiry*, 7, 679-692.
- KINCHELOE, J. J. (2005) On to the Next Level: Continuing the Conceptualization of the Bricolage. *Qualitative Inquiry*, 11, 323-350.
- KINCHELOE, J. L. & BERRY, K. S. (2004) *Rigour and Complexity in Educational Research: Conceptualizing the bricolage*, Maidenhead, Open University Press.

- KLEIN, J. T. (2004) Interdisciplinarity and complexity: An evolving relationship. *Emergence: Complexity & Organization. An International Transdisciplinary Journal of Complex Social Systems*, 6, 2-10.
- KNIGHT, P. T. (2001) Complexity and Curriculum: a process approach to curriculum-making. *Teaching in Higher Education*, 6, 369-381.
- KUHN, L. (2008) Complexity and educational research: a critical reflection. *Educational Philosophy and Theory*, 40, 177-189.
- KUMAR, M. (2009) *Quantum: Einstein, Bohr and the Great Debate About the Nature of Reality* London, Icon Books.
- KVALE, S. (1996) *InterViews: An Introduction to Qualitative Research Interviewing*, Thousand Oaks, CA, SAGE.
- LATHER, P. (1991) *Getting Smart: Feminist Research and Pedagogy With/in the Postmodern*, London, Routledge.
- LATHER, P. (2007) *Getting Lost: Feminist Efforts towards a Double(d) Science*, Albany, State University of New York Press.
- LAVE, J. & WENGER, E. (1991) *Situated Learning: Legitimate Peripheral Participation*, Cambridge, Cambridge University Press.
- LAVERTY, M. J. (2009) Book Review: Gert J.J. Biesta, *Beyond Learning: Democratic Education for a Human Future*. *Studies in Philosophy & Education*, 28, 659-576.
- LAW, J. (2004) *After Method: Mess in Social Science Research*, London, Routledge.
- LAW, J. & HASSARD, J. (Eds.) (1999) *Actor-Network Theory and After*, Oxford and Keele, Blackwell and the Sociological Review.
- LAWLER, S. (2008) *Identity: Sociological Perspectives*, Cambridge, Polity Press.
- LEACH, J. & SCOTT, P. (2003) Individual and Sociocultural Views of Learning in Science Education. *Science and Education*, 12, 91-113.
- LEAT, D. (1999) Rolling the Stone Uphill: teacher development and the implementation of Thinking Skills programmes. *Oxford Review of Education*, 25, 397-403.
- LET'S THINK COGNITIVE ACCELERATION (2009) *Cognitive Acceleration: Theory and Pedagogy*. Cognitive Acceleration Associates.
- LINCOLN, Y. S. (2001) An Emerging New Bricoleur: Promises and Possibilities—A Reaction to Joe Kincheloe's "Describing the Bricoleur". *Qualitative Inquiry*, 7, 693-696.
- LOVELESS, D. & GRIFFITH, B. (2012) Invited Address to the Chaos and Complexity SIG: Paradoxes Amongst Chaos, Complexity and Coherence. *American Educational Research Association Annual Conference*. Vancouver, Canada.
- LOWE, R. (2007) *The Death of Progressive Education: How teachers lost control of the classroom*, Oxford, Routledge.
- MACLURE, M. (2006) The bone in the throat: some uncertain thoughts on baroque method. *International Journal of Qualitative Studies in Education*, 19, 729–745.
- MANKE, M. (1997) *Classroom Power Relations: Understanding Student-Teacher Interaction*, Mahwah, NJ, Lawrence Erlbaum Associates.
- MAROULIS, S., GUIMERÀ, R., PETRY, H., STRINGER, M. J., GOMEZ, L. M., AMARAL, L. A. N. & WILENSKY, U. Complex Systems View of Educational Policy Research. *Science*, 330, 38-39.
- MARSH, C. (2004) *Key Concepts for Understanding Curriculum*.
- MAZZEI, L. A. & MCCOY, K. (2010) Thinking with Deleuze in Qualitative Research. *International Journal of Qualitative Studies in Education*, 23, 503-509.

- MCANDREW, D. A. (1997) Chaos, Complexity, and Fuzziness: Science Looks at Teaching English. *English Journal*.
- MCCALL, L. (2005) The Complexity of Intersectionality. *Signs: Journal of Women in Culture and Society*, 30, 1771-1800.
- MCMURTRY, A. (2006) Linking complexity with cultural historical activity theory. *International Journal of Research & Method in Education*, 29, 209-219.
- MCMURTRY, A. (2008) Complexity Theory 101 for Educators: A Fictional Account of a Graduate Seminar. *McGill Journal of Education*, 43, 265-282.
- MCMURTRY, A. (2011) The complexities of interdisciplinarity: Integrating two different perspectives on interdisciplinary research and education. *Complicity: An International Journal of Complexity & Education*, 8, 19-35.
- MERRIAM, S. B. (1988) *Case Study Research in Education*, San Francisco, CA, Jossey Bass.
- MILES, M. B. & HUBERMAN, A. M. (1994) *Qualitative data analysis : an expanded sourcebook* Thousand Oaks, CA, SAGE.
- MILIBAND, D. (2003) Teaching in the 21st century: Full text of speech delivered to the North of England Conference, January 2003. *The Guardian*.
- MILLAR, R. & OSBORNE, J. (1998) *Beyond 2000: Science Education for the Future*, London, King's College London.
- MINNER, D. D., LEVY, A. J. & CENTURY, J. Inquiry-Based Science Instruction--What Is It and Does It Matter? Results from a Research Synthesis Years 1984 to 2002. *Journal of Research in Science Teaching*, 47, 474-496.
- MITCHELL, M. (2009) *Complexity: A Guided Tour*, USA, Oxford University Press.
- MOJE, E. B. & LUKE, A. (2009) Literacy and Identity: Examining the Metaphors in History and Contemporary Research. *Reading Research Quarterly*, 44, 415-437.
- MOORE, R. & YOUNG, M. (2001) Knowledge and the Curriculum in the Sociology of Education: towards a reconceptualisation. *British Journal of Sociology of Education*, 22, 445-461.
- MORRISON, K. (2003) Complexity theory and curriculum reforms in Hong Kong. *Pedagogy*, 11, 279-302.
- MORRISON, K. (2005) Structuration theory, habitus and complexity theory: elective affinities or old wine in new bottles? *British Journal of Sociology of Education*, 26, 311-326.
- MORRISON, K. (2008) Educational philosophy and the challenge of complexity theory. *Educational Philosophy and Theory*, 40, 19-34.
- MOSELEY, D., BAUMFIELD, V., ELLIOTT, J., HIGGINS, S., MILLER, J. & NEWTON, D. P. (2005) *Frameworks for Thinking: A Handbook for Teaching and Learning*, Cambridge, Cambridge University Press.
- MUBAYI, A., GREENWOOD, P., WANG, X. H., CASTILLO-CHAVEZ, C., GORMAN, D. M., GRUENEWALD, P. & SALTZ, R. F. (2011) Types of Drinkers and Drinking Settings: An Application of a Mathematical Model. *Addiction*, 106, 749-758.
- NAMUKASA, I. & SIMMT, E. (2003) Collective Learning Structures: Complexity Science Metaphors for Teaching.
- OLSSSEN, M. (2008) Foucault as complexity theorist: overcoming the problems of classical philosophical analysis. *Educational Philosophy and Theory*, 40, 96-117.
- ORESQUES, N., SHRADER-FRECHETTE, K. & BELITZ, K. (1994) Verification, validation, and confirmation of numerical models in the earth sciences. *Science* 263, 641-646.

- OSBERG, D. (2005a) Curriculum, Complexity and Representation: Rethinking the epistemology of schooling through complexity theory. *Education*. Milton Keynes, The Open University.
- OSBERG, D. (2005b) Redescribing 'Education' in Complex Terms. *Complicity: An International Journal of Complexity & Education*, 2, 81-83.
- OSBERG, D. (2009a) "Enlarging the space of the possible" around what it means to educate and be educated. *Complicity: An International Journal of Complexity & Education*, 6, iii-ix.
- OSBERG, D. (2009b) Towards a non-normative, normative curriculum. *Conference of the International Association for the Advancement of Curriculum Studies*. Somerset-West, South Africa.
- OSBERG, D. (2010a) Taking Care of the Future. IN OSBERG, D. & BIESTA, G. (Eds.) *Complexity Theory and the Politics of Education*. Rotterdam, Sense.
- OSBERG, D. (2010b) Taking Care of the Future? The Complex Responsibility of Education and Politics. IN OSBERG, D. & BIESTA, G. (Eds.) *Complexity Theory and the Politics of Education*. Rotterdam, Sense.
- OSBERG, D. & BIESTA, G. (2007) Beyond Presence: Epistemological and Pedagogical Implications of "Strong" Emergence. *Interchange*, 38, 31-51.
- OSBERG, D. & BIESTA, G. (2008) The emergent curriculum: navigating a complex course between unguided learning and planned enculturation. *Journal of Curriculum Studies*, 40, 313-328.
- OSBERG, D. & BIESTA, G. (2010) The end/s of education: complexity and the conundrum of the inclusive educational curriculum. *International Journal of Inclusive Education*, 14, 593-607.
- OSBERG, D., BIESTA, G. J. J. & CILLIERS, P. (2008) From representation to emergence: complexity's challenge to the epistemology of schooling. *Educational Philosophy and Theory*, 40, 213-227.
- OSBORNE, J. & COLLINS, S. (2001) Pupils' views of the role and value of the science curriculum: a focus group study. *International Journal of Science Education*, 23, 441-467.
- OSBORNE, J., COLLINS, S., RATCLIFFE, M., MILLAR, R. & DUSCHL, R. A. (2003a) What "Ideas-about-Science" Should Be Taught in School Science? A Delphi Study of the Expert Community. *Journal of Research in Science Teaching*, 40, 692-720.
- OSBORNE, J., ERDURAN, S. & SIMON, S. (2004) Enhancing the Quality of Argumentation in School Science. *Journal of Research in Science Teaching*, 41, 994-1020.
- OSBORNE, J., SIMON, S. & COLLINS, S. (2003b) Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, 25, 1049-1079.
- PHELAN, A. M. (2004) Rationalism, Complexity Science and Curriculum: A Cautionary Tale. *Complicity: An International Journal of Complexity & Education*, 1, 9-17.
- PHELAN, S. E. (2001) What is Complexity Science, Really? *Emergence*, 3, 120-136.
- PHELPS, R. (2005) The Potential of Reflective Journals in studying Complexity 'In Action'. *Complicity: An International Journal of Complexity and Education*, 2, 37-54.
- PHELPS, R. & HASE, S. (2002) Complexity and Action Research: Exploring the Theoretical and Methodological Implications. *Educational Action Research*, 10, 507-524.

- PICARD, E. K. (2010) A Radical Relational Agency: Foucault, Complexity Theory and Environmental Resistances. *Faculty of Arts, School of Modern Languages and Cultures*. Nottingham, University of Nottingham.
- PINAR, W. F. & IRWIN, R. L. (Eds.) (2005) *Curriculum in a New Key: The Collected Works of Ted T. Aoki*, Mahwah, NJ, Lawrence Erlbaum.
- POPKEWITZ, T. S. (2009) Curriculum study, curriculum history, and curriculum theory: the reason of reason. *Journal of Curriculum Studies*, 41, 301-319.
- POPKEWITZ, T. S. & BRENNAN, M. (Eds.) (1998) *Foucault's Challenge: Discourse, Knowledge and Power in Education*, New York, Teachers College Press.
- PORTELLI, J. P. (1993) Exposing the hidden curriculum. *Journal of Curriculum Studies*, 25, 343-358.
- PRATT, S. & TRUEIT, D. (2011) Complex conversations: Rigorous, relevant, rich and relational moments of learning. *American Educational Research Association 2011*. New Orleans.
- PRESKILL, H. (2009) Reflections on the dilemmas of conducting environmental evaluations. *New Directions for Evaluation*, 97-103.
- PRIESTLEY, M. (2011) Schools, teachers, and curriculum change: A balancing act? *Journal of Educational Change*, 12, 1-23.
- PRIESTLEY, M., EDWARDS, R., PRIESTLEY, A. & MILLER, K. (2012) Teacher Agency in Curriculum Making: Agents of Change and Spaces for Manoeuvre. *Curriculum Inquiry*, 42, 191-214.
- PRIGOGINE, I. (1997) *The End of Certainty: Time, Chaos and the New Laws of Nature*, New York, NY, The Free Press.
- PRIGOGINE, L. & STENGERS, I. (1985) *Order out of Chaos*, London, Flamingo.
- PRING, R. (2000a) Editorial: educational research. *British Journal of Educational Studies*, 48, 1-9.
- PRING, R. (2000b) *Philosophy of Educational Research*, London, Continuum.
- PROJECT, T. F. (2010) Implementing Inquiry-Based Science Education. www.fibonacci-project.eu.
- PROULX, J. (2008) Some Differences between Maturana and Varela's Theory of Cognition and Constructivism. *Complicity: An International Journal of Complexity & Education*, 5, 11-26.
- QCA (1999) The National Curriculum: Handbook for Secondary Teachers in England. IN DFES (Ed.), DfES and QCA.
- QCA (2004) National Curriculum Handbook for Secondary Teachers in England. IN DFES (Ed.) Revised ed., DfES and QCA.
- QCA (2007a) National Curriculum for England and Wales London, DfES and QCA.
- QCA (2007b) National Curriculum for England and Wales. QCA.
- QCA (2007c) The New Secondary Curriculum: What has Changed and Why? , QCA.
- QCA (2007d) News release: QCA launches the new secondary national curriculum. London, QCA.
- RADFORD, M. (2006) Researching classrooms: complexity and chaos. *British Educational Research Journal*, 32, 177-190.
- RADFORD, M. (2008) Complexity and truth in educational research. *Educational Philosophy and Theory*, 40, 144-157.

- RASMUSSEN, J. (2010) Increasing Complexity by Reducing Complexity: A Luhmannian approach to learning. IN OSBERG, D. & BIESTA, G. (Eds.) *Complexity Theory and the Politics of Education*. Rotterdam, Sense.
- RICHARDS, L. (2005) *Handling Qualitative Data: A Practical Guide*, Thousand Oaks, CA, SAGE.
- RICHARDSON, K. & CILLIERS, P. (2001) What Is Complexity Science? A View from Different Directions. *Emergence*, 3, 5-22.
- RICHARDSON, K. A., CILLIERS, P. & LISSACK, M. (2001) Complexity Science: A "Gray" Science for the "Stuff in Between". *Emergence*, 3, 6-18.
- RITZER, G. & GOODMAN, D. J. (2004) *Sociological Theory*, McGraw Hill.
- ROBINSON, K. (2006) 'Ken Robinson says schools kill creativity'. *TEDtalks*. TED.
- ROCA, C. P. & HELBING, D. (2011) Emergence of social cohesion in a model society of greedy, mobile individuals. *PNAS*, 108, 11370-11374.
- RSA (2008-2012) Opening Minds.
- RYDER, J. & BANNER, I. (2011) Multiple Aims in the Development of a Major Reform of the National Curriculum for Science in England. *International Journal of Science Education*, 33, 709-725.
- SANDBOTHE, M. (2001) *The Temporalization of Time: Basic Tendencies in Modern Debate on Time in Philosophy of Science*, Lanham, MD & Oxford, Rowan and Littlefield.
- SCOTT, D. (2000) *Realism and Educational Research: New Perspectives and Possibilities*, London, Routledge Falmer.
- SEMETSKY, I. (2005) Not by breadth alone: Imagining a Self-Organised Classroom. *Complicity: An International Journal of Complexity & Education*, 2, 19-36.
- SEMETSKY, I. (2006) *Deleuze, Education and Becoming*, Rotterdam, NL, Sense.
- SEMETSKY, I. (2008) On the creative logic of education, or: re-reading Dewey through the lens of complexity science. *Educational Philosophy and Theory*, 40, 83-95.
- SILVERMAN, D. (2000) *Doing Qualitative Research*, London, Sage.
- SIMONS, M. & OLSSSEN, M. (2010) The School and Learning Apparatus. IN OSBERG, D. & BIESTA, G. (Eds.) *Complexity Theory and the Politics of Education*. Rotterdam, Sense.
- SJØBERG, S. & SCHREINER, C. (2007) Perceptions and images of science and science education. IN CLAESSENS, M. (Ed.) *Communicating European Research*. Heidelberg, Springer.
- SKINNER, B. F. (1953/2005) *Science and Human Behavior*. The B. F. Skinner Foundation.
- SLATTERY, P. (2006) *Curriculum Development in the Postmodern era*, New York, Routledge.
- SMITH, J. & JENKS (2006) *Qualitative Complexity: Ecology, cognitive processes, and the re-emergence of structures in post-humanist social theory*, Abingdon, Routledge.
- SMITHERMAN PRATT, S. (2008a) Bifurcations are Not Always Exclusive. *Complicity: An International Journal of Complexity & Education*, 5, 125-128.
- SMITHERMAN PRATT, S. (2008b) Complex Constructivism: Rethinking the Power Dynamics of "Understanding". *Journal of the Canadian Association for Curriculum Studies*, 6.
- SOUTHWORTH, G. (2004) A Response from the National College for School Leadership. *Educational Management Administration & Leadership*, 32, 339-354.
- ST JOHN, J. (2000) Changing Conceptions of Human Intelligence and Reasoning: Implications for the Classroom. *Australian Journal of Education*.
- ST. PIERRE, E. & PILLOW, W. (2000) *Working the Ruins: Feminist Poststructural Theory and Methods in Education*, London, Routledge.
- STAKE, R. E. (1994) Case studies. IN DENZIN, N. K. & LINCOLN, Y. S. (Eds.) *Handbook of Qualitative Research*. London, SAGE.

- STAKE, R. E. (1995) *The Art of Case Study Research*, Thousand Oaks, CA, SAGE.
- STAKE, R. E. (2003) Case Studies. IN DENZIN, N. K. & LINCOLN, Y. S. (Eds.) *Strategies of Qualitative Inquiry*. Thousand Oaks, CA, SAGE.
- STENHOUSE, L. (1985) Case Study Methods. IN HUSEN, T. & POSTLETHWAITE, T. N. (Eds.) *International Encyclopedia of Education*. First ed. Oxford, Pergamon.
- SUMARA, D. J. & DAVIS, B. (1997) Enlarging the space of the possible: Complexity, complicity, and action research practices. IN CARSON, T. & SUMARA, D. J. (Eds.) *Action Research as a Living Practice*. New York, Peter Lang.
- SWANN, J. & PRATT, J. (Eds.) (1999) *Improving Education: Realist Approaches to Methods and Research*, London, Cassell.
- TABER, K. (2008) Towards a Curricular Model of the Nature of Science. *Science and Education*, 17, 179-218.
- TEAM, S. C. S. P. (2003) 21st Century Science-a new flexible model for GCSE science. *School Science Review*, 85, 27-34.
- THRIFT, N. (1999) The Place of Complexity. *Theory, Culture & Society*, 16, 31-69.
- TLRP, E. (2001-2006) Learning How to Learn: A Project of the ESRC Teaching and Learning Research Programme. ESRC TLRP.
- TOFFLER, A. (1984) Foreword: Science and Change. IN PRIGOGINE, I. & STENGERS, I. (Eds.) *Order Out of Chaos: Man's New Dialogue with Nature*. London, Collins.
- TOMLINSON, M. (2004) 14-19 Curriculum and Qualifications Reform. Final Report of the Working Group on 14-19 Reform. IN SKILLS, D. F. E. A. (Ed.), DfES Publications.
- TOOLEY, J. (1998) Education Research: A critique. London, OfSTED.
- TOPLIS, R., GOLABEK, C. & CLEAVES, A. (2010) Implementing a new science National Curriculum for England: how trainee teachers see the How Science Works strand in schools. *The Curriculum Journal*, 21, 65-76.
- TOWNSEND, G. C., KIM, M. & SANKEY, D. (2012) Dynamic Systems (Complexity) theory as a new conceptual model for researching PBL in dental education. *European Journal of Dental Education*, 16, 43-51.
- TYLER, R. W. (1949) *Basic Principles of Curriculum and Instruction*, Chicago, University of Chicago Press.
- URRY, J. (2005) The Complexity Turn. *Theory, Culture and Society*, 22, 1-14.
- VON GLASERFELD, E. (1995) *Radical Constructivism: A way of knowing and learning*, London, Falmer Press.
- VYGOTSKY, L. S. (1978) *Mind in Society: The development of higher psychological processes*, Boston, MA, Harvard University Press.
- WALBY, S. (2007) Complexity Theory, Systems Theory and Multiple Social Inequalities. *Philosophy of the Social Sciences*, 37, 449-470.
- WALDROP, M. M. (1992) *Complexity: The Emerging Science at the Edge of Order and Chaos*, London, Penguin.
- WALLACE, C. S. & PRIESTLEY, M. (2012) Teacher beliefs and the mediation of curriculum innovation in Scotland: A socio-cultural perspective on professional development and change. *Journal of Curriculum Studies*, 43, 357-381.
- WARREN, K., FRANKLIN, C. & STREETER, C. L. (1998) New Directions in Systems Theory: Chaos and Complexity. *Social Work*.
- WEEDON, C. (2004) *Identity and Culture: Narratives of Difference and Belonging*, Open University Press.

- WEGERIF, R., POSTLETHWAITE, K., SKINNER, N., MANSOUR, N., MORGAN, A. & HETHERINGTON, L. (In preparation for 2012/13) Dialogic Science Education for Diversity. IN WEGERIF, R. & MANSOUR, N. (Eds.) *Science Education for Diversity*. New Jersey, Springer Science.
- WILSON, N. S. & BAI, H. (2010) The Relationships and Impact of Teachers' Metacognitive Knowledge and Pedagogical Understandings of Metacognition. *Metacognition and Learning*, 5, 269-288.
- WOLF-BRANIGIN, M. (2009) Applying Complexity and Emergence in Social Work Education. *Social Work Education*, 28, 115-127.
- YIN, R. K. (1984) *Case Study Research: Design and Methods*, Beverley Hills, CA, SAGE.
- YOON, S. (2007) An Evolutionary Approach to Harnessing Complex Systems Thinking in the Science and Technology Classroom. *International Journal of Science Education*, 29.
- YOUNGBLOOD-JACKSON (2012) Foucault's Power/Knowledge Reading. 'Thinking with theory in qualitative research': AERA 2012 Professional Development Workshop ed.
- YOUNGBLOOD JACKSON, A. & MAZZEI, L. A. (2012) *Thinking with theory in qualitative research: Viewing across multiple perspectives*, Abingdon, Routledge.

Appendices

Appendix 1: Interview schedules

Interviews were conducted in loose, semi-structured ways. For the teacher interviews, a schedule was developed as shown below, but the conversations with teachers regularly took different directions based on related lesson observations or comments from the teachers.

Teacher Interviews

1. What are you like as a teacher? How do you see yourself as a teacher?
2. What is your approach to lesson planning a) in your subject area and b) in Opening Minds
3. How much do you feel your advance planning is different in Opening Minds as the curriculum develops?
4. How would you describe the students in Opening Minds?
5. Do you feel you are able to be flexible in your teaching during the lessons in opening minds? how does this compare with your subject-based teaching?
6. Has teaching Opening Minds affected the way you teach your subject? If so, how?
7. Do you think the subject you teach affects the way you teach opening minds? if so, how?
8. Do you teach a Year 7 or 8 group in your subject area, and if so, do you use CLIPS in your lessons with them. If so, why, if not, why not?
9. Do you think learning Opening Minds has made a difference to the way students' learn, behave or react in your subject lessons?
10. Do you find the students' response to your teaching in Opening Minds more or less unpredictable than in your subject teaching (or the same) and why do you think this is?

Student Interviews

An annotated example of a student interview schedule is included below. Again, these conversations regularly went in other directions and these questions were used as a guide and to 'break the ice'.

Student Interview Notes



Questions/themes:

1. Can you tell me a little bit about yourself? What tutor group you're in, what sort of things you like doing...
2. Can you give me an example of something you've done in school recently that you really liked? + *Something had to do with drama + like religion masks*
3. What is your tutor group like? *Friendly - a bit amusing*
4. Can you describe what you think you are like in lessons? *Work hard, keep on trying your best. Friendly*
5. If you are working in a group, how do you usually work? Do you think you learn well in a group and why?
6. If you are working on your own, how do you approach what you're doing? Do you think you learn well on your own and why?
7. *What do you think of* ~~Describe~~ *Opening Minds?* *what*
8. Do you think you get a lot out of Opening Minds?
9. What is your teacher like? Can you describe your OH teacher in 5 words? *Funny, friendly, helpful, calm.*

10. What sort of things does your teacher talk to you about in lessons in OH?

11. What sorts of subjects do you like/dislike and why?

*Tech - making things
+ English - not creative writing. Maths - don't like adding.*

12. How do you like to be grouped in lessons?

13. What do you think of the cooperative learning type activities? How often do you do them, do you think?

*OH, English
Good, because learn things! not in Maths, Science, Geography.
Can you tell me what sorts of things you learned about in OH start? Do you ever use ideas from OH in other lessons? Do the teachers in other lessons ever talk about ideas from OH (e.g. the CLIPS)?
How to make things? learn about history*

14. What can you remember about the Learn 2 Achieve you did right at the start? Do you ever use ideas from OH in other lessons? Do the teachers in other lessons ever talk about ideas from OH (e.g. the CLIPS)?

15. How much choice do you have about what you do in school? Do you find it easy to tell teachers what occurs to you in lessons? Is it easy to ask questions in lessons? What sorts of things do you ask about?

16. What do you think the rest of your class think about OH?

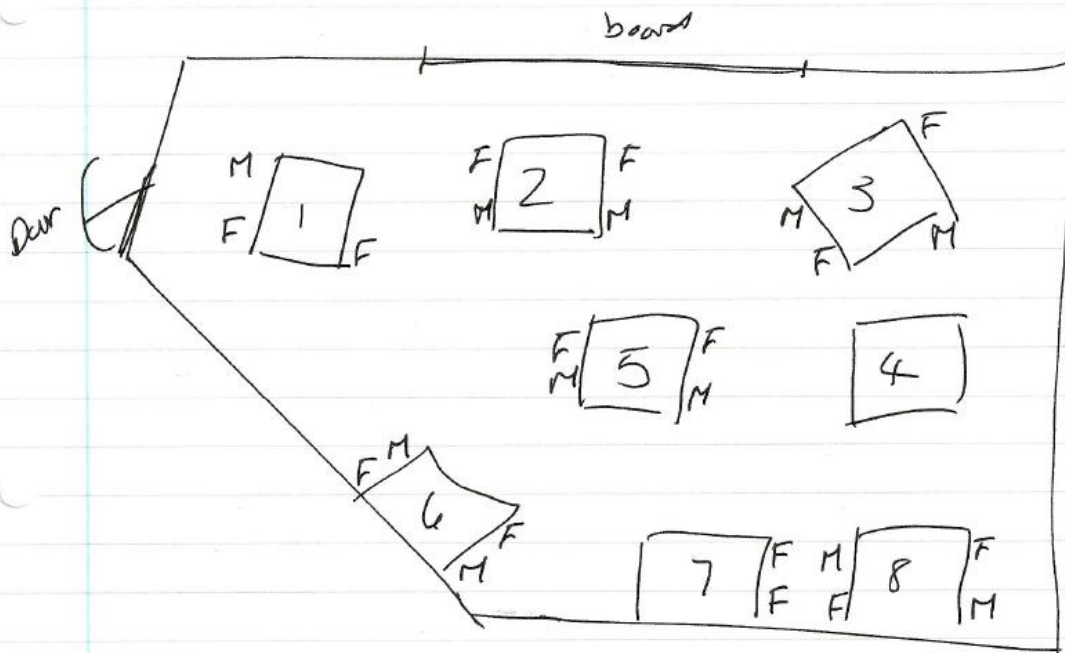
17. What sort of thing do you think you might like to do when you leave school? How do you think the things you are doing in school at the moment might help you in the future?

- what do you think it important for you to learn about?

Appendix 2: Lesson Observation Schedule and example of notes

Teacher:	Class:	Number of Students
Explicit mention of elements related to new curriculum:		
C1 C2 C3 C4 L1 L2 L3 L4 L5 L6 I1 I2 P1 P2 P3 P4 S1 S2 S3 S4 S5	CCDs: Identity Enterprise Healthy lifestyles Community participation Global dimension Technology Creativity PLTS: Independent enquirers Creative thinkers Reflective learners Team workers Self-managers Effective participants	
Implicit mention of elements related to the new curriculum:		

Observation notes – open-ended. Initial aim to focus on planning and flexibility



The students making their ideas are looking quite excited, lots of interest in the things brought in. One student asks another table to have a look at what they've brought. I work with table 1 as there are 3 there. As time continues to the end of the 2 min (there is a turn timer on the board) ~~some~~ a few students are on their feet talking to other tables and sharing their stuff.

11:45 Teacher asks them and asks them to move their chairs into a circle, taking ancestor info with.

12:30 Up to now, each student has told a story in the circle about their families /ancestors - really interesting stories! Pirates, aristocrats, war heroes, links to Jamaica, America, Poland, India.
 3 mins to get oxygen going + look at each other's pictures and artefacts. They get up and start talking to each other + many things.

Appendix 3: Questionnaires and Procedures

Teacher Questionnaire

The teacher questionnaire was created following discussion with the leaders of OM in the case study school, James and Daniel. It was designed to be relatively short and conducted via an online system, limesurvey, for ease of access for teachers. Following initial development, the questionnaire was checked with Keith Postlethwaite for academic validity, and then tested by Daniel (OM team leader) for expert and face validity. A simple Likert scale was used, with some opposing pairs of statements to check for reliability of data entry. The teacher survey was exported into excel for initial analysis, with some aspects imported in to SPSS for statistical analysis. Since the questionnaire is online, a copy is not included here, but can be found following this link, where the questionnaire remains active but any data entered is saved in a test file only:

<http://elac.exeter.ac.uk/limesurvey/index.php?sid=24437&lang=en>

Student Questionnaire

A pilot version of the questionnaire was created and completed by one tutor group in the case study school in Year 10 (aged 14-15). This pilot aimed to check that the questions were clear for the students and that they understood how to complete the questionnaire. After completing the questionnaire, the students were asked to annotate their responses if there were questions that had not made sense to them. Although these students were older than the target group, it was felt that this initial pilot stage could achieve its aims without removing a tutor group from the KS3 sample by using them as a pilot group.

The questionnaire was also checked with Keith Postlethwaite for academic guidance and expert validity, and with the OM team leaders for face validity. As with the teacher questionnaire, where a Likert scale was used, some paired questions were included to check for reliability in data entry, which resulted in removal of some completed questionnaires during data entry where this highlighted that questionnaires had not been properly completed.

Three versions of the student questionnaire were created: one for Year 7, in which OM questions were phrased in the present tense, one for Year 8, with OM questions phrased in the past tense, and one for Year 9 without the questions about OM.

Students completed the questionnaires during a tutor period, and instructions were provided for KS3 tutors to administer the questionnaire to ensure reliability and validity in completion, with notes on anonymity and confidentiality. These included guidance as to the support tutors should provide to help students with special educational needs complete the questionnaire.

Student responses to open ended questions about what OM involves were analysed using 'word clouds' in which the regularity of the word is counted and represented visually by size. These were produced using a free online tool.

Following completion, the questionnaire results were transferred in to SPSS. Data was tested for normality using the Kolmogorov-Smirnoff test combined with plotted data as advocated by Field (2000). This was used to guide choice of statistical tests in later data analysis. The reliability of the different scales in the questionnaires was also tested using Cronbach's-alpha. Removal of the items related to how 'easy' or 'hard OM is produced an 'opinions of OM scale' with Cronbach's-alpha = 0.828, suggesting this is a reliable scale. The attitude scale 'general opinions of OM' had a lower alpha = 0.781. Factor analysis on this set of items produced three factors using varimax rotation, which were labelled 'attitude to lesson/learning environment', 'understanding how to do school work' and 'opinions of learning groups'. Of these, the former was a reliable sub-scale (Cronbach's-alpha = 0.843) but the latter two showed low alpha scores. Analysis of the questionnaire therefore proceeded through comparison of individual elements in these scales as well as through comparison between groups of the summed scales where these were deemed reliable. In the main, non-parametric tests were used to identify significant differences, and effect sizes calculated. Much of this analysis is not reported in this thesis but was used to provide a report for the school outlining the differences in attitude between the different year groups to give some insight in to students' opinions of Opening Minds and attitudes to school in general.

Year 7 Student Questionnaire - KS3 Curriculum Research

For this activity, please work on your own and try to think of answers that are true for *you*. Thank you for taking part. You don't have to fill in your name if you don't want to.

Name: _____ Tutor Group: _____ Gender: M/F (please circle)

Opening Minds - this section is all about your OM lessons:

In Opening Minds, I am learning to:-

In the table below is a list of statements, with boxes next to them for if you agree or disagree with the statement. Please tick the box that best fits your opinion.

Statement	Strongly Disagree	Disagree	Don't mind	Agree	Strongly Agree
I think the work we do in OM is interesting					
I look forward to OM lessons					
I don't think the work we do in OM is important					
OM helps me learn in other subjects					
I think the work we do in OM is hard					
I understand what the CLIPS are about					
I don't understand why we have OM					
I don't use ideas from OM in my other lessons					
I think the work we do in OM is easy					

I like the way I am grouped in OM lessons					
I feel I can talk to my OM teacher					
OM is useful for my life outside school					

General Questions:

My three favourite subjects are: _____, _____ and _____

My three least favourite subjects are: _____, _____ and _____

Activities that help me learn in lessons include (please circle):

Working on a project; Working on my own; Working in groups; self-assessing my work; having my peers assess my work; the teacher assessing my work; doing a presentation; working on the computer; written work; practical activities

Are there any other lesson activities that help you learn? _____

Activities that don't help me learn in lessons include (please circle):

Working on a project; Working on my own; Working in groups; self-assessing my work; having my peers assess my work; the teacher assessing my work; doing a presentation; working on the computer; written work; practical activities

Are there any other lesson activities that don't help you learn? _____

In the table below is a list of statements, with boxes next to them for if you agree or disagree with the statement. Please tick the box that best fits your opinion.

Statement	Strongly Disagree	Disagree	Don't mind	Agree	Strongly Agree
My subjects are useful for what I want to do after school					
I understand the work I am given to do					
My subject teachers talk about the CLIPS competencies					
I feel I have made progress in my learning at Kingsbridge					
I see links between the work I do in different subjects					
I like most of my teachers					
Targets help me to improve my work					
I don't work well when I'm with my friends					
I think that homework is a waste of time					
I work best when I'm in planned seating					
I don't understand how to achieve the targets I am set					
The way I work in lessons effects the rest of the class					
My parents are interested in what I do in school					
My teachers are enthusiastic					
I get a choice about what I do in lessons					
I prefer working in a group					
My teachers listen to me					
I think my teachers notice if I'm not involved in the lesson					
What I do in lessons doesn't matter					
My teacher makes a big difference to how much I learn in lessons					

Appendix 4: Example of matrix analysis

Notes on how these matrices work:

I have done a separate matrix for the key ideas discussed in the T.F – agency, power, reflexivity, identity. For each, I've plotted it against ideas of incremental change and emergent change. On the computer, it looks like they are proper categories, but in my head it is a bit more like a continuum, hence the right or left justifying in the columns. There is a problem with thinking of agency/power etc as high or low given that they are in relation, so I've borne this in mind when placing summaries of teacher quotes or ideas, as it isn't necessarily the case that if they talk in a way that gives a sense of their own agency they are in any way diminishing the students' agency, for example.

I've used summaries of teacher ideas from interviews because quotes are often too long. They are colour coded. Purple relates (mainly) to curriculum/pedagogy, red relates to reflection/assessment, and blue relates to interactions. I just picked the colour for the main idea because they do link up and relate (e.g. reflection as a form of pedagogy).

The idea is that you can see in these that it is a more complicated picture than e.g simply being about teachers with high sense of agency also have a more experimental/emergent approach, or low agency linked to complexity reduction. You can look at them and see that some teachers lean more one way than another, and explore where the tensions are. And I think that mapping out like this shows where, for teachers as a group of OM teachers or as individuals, complexity ideas such as emergence, or relational notions of power or agency, or complexity reduction, might be helpful.

	Incremental	Emergent
Low sense of Agency	<p>WK: discusses why not using OM ideas in maths – lack of time, constrained by maths lesson objectives and suggests needs to be written into scheme to help teachers think about it.</p> <p>WK: discusses belief that students need to formalise ‘Learn 2’ through notes and revision and tests...but in tension with enabling them to use these ideas in their own learning in more open-ended ways in the future.</p> <p>JE: describes subject-based teaching as bound by curriculum (contrasts with agency and experiment/emergence in OM teaching)</p>	<p>WK lines 197-202: got involved because was asked to by SMT but can bring ‘enthusiasm and creativity to it’ and is now ‘sold’ on it, talks about how much practice has changed.</p> <p>WK: Instant reaction to new curriculum is, ‘god, I’ve got to do this now’.</p>
High sense of Agency	<p>WK: ‘I’m creating more opportunities to sit down and work with them one-to-one’</p> <p>WK: talks about clips review sheet created – agency in that creating sheet away from schemes of work, but uses traditional technique to achieve outcome-based aims.</p> <p>JE: but whilst he talks of metacognition (linked to agency), still also looking for ways to do things that are good or better...[not sure if this is really incremental or emergent, could be either. Not sure what to do with this one]</p> <p>JE: Element of choice for teachers in relation to training needs, but new curriculum presented as a pedagogical ‘toolkit’ in quite an incremental style.</p>	<p>WK: Anecdote about students choosing groups in their own way</p> <p>JE: idea that when planning om, wanted it to be something different, not looking like anything done before, not traditional</p> <p>JE: being aware of being in a rut, trying to change</p> <p>JE: talks about OM being about metacognition and implies strengthening of student agency. Implies also that don’t know where you are going with it.</p>

Appendix 5: Certificate of ethical approval

Note: This certificate was produced in the early stages of the project when I intended to focus on Earth science. As outlined in the thesis, as the project developed, I reflexively returned to consider the ethics of the case.

STAFF ETHICAL



School of Education and Lifelong Learning

Academic Staff Research

CERTIFICATE OF ETHICAL RESEARCH APPROVAL

To obtain a Certificate of Approval, you need to fill out this form and have it signed by the Chair of the School's Research Ethics Committee (see below).

COMPLETE THE FORM ON COMPUTER (it will expand to contain the text you enter).

DO NOT COMPLETE BY HAND.

Name of principal investigator: Lindsay Hetherington

Names of collaborating investigators:

Title of Project: Responses to curriculum change at KS3 using a complexity approach

Brief Description of Project: The researcher will work with two participating schools to explore teachers' and students' responses to the new KS3 curriculum, with particular reference to earth science. The project will use complexity theory as the framework for the research, leading to a focus on relationships between teachers, students and the curriculum and the emergent patterns of interaction and development of conceptual ecologies that arise from those relationships. Interviews and classroom observation will be the primary methods of data collections, however, a bricolage methodology will allow the project's methods to develop through time in response to the emergent patterns.

Project Contact Point (incl. Email/telephone nos.) L.Hetherington@Ex.ac.uk;
01392 264826; 07766310731

Give details of the participants in this research (giving ages of any children and/or young people involved):

Members of staff and students are the two schools will be the research participants (and possibly some parents also). The students will be from the KS3 cohort, aged 11-14. The early stages of the research will focus on Year 7 (11-12 year-olds).

Give details regarding the ethical issues of informed consent, anonymity and confidentiality (with special reference to any children or those with special needs) a blank consent form can be downloaded from the SELL student access on-line documents:

Since the research methods may need to adapt in response to the complexity of schools and classrooms, informed consent will be sought on an ongoing basis, without making an assumption that if a participant agrees to be interviewed or observed at one point in the project, they will also wish to take part in those same activities at a later date or a different sort of activity. Participants will be offered access to field notes and observations. Confidentiality and anonymity of participants will be maintained. However, child protection guidance within the schools will be followed, although the research is unlikely to involve discussion of any sensitive topics. Where the research involves activities outside the normal school activities, for example interviewing students, informed consent will be sought from both children and their parents/guardians. Some students may have special educational needs – support will be sought as necessary for any research activities outside the normal school pattern if a child with a SEN wishes to participate in the project. This may include differentiation of concept mapping activities, for example, or TA support in interviews. Where methods are adapted and developed, notes of ethical considerations and the approaches taken to them will be kept in the research journal and discussion of ethical issues with the PhD supervisors will continue throughout the project.

Give details of the methods to be used for data collection and analysis and how you would ensure they do not cause any harm, detriment or unreasonable stress:

Primary methods for data collection and analysis will be interviews and lesson observations. Participants will be sought on a voluntary basis and their wishes respected should they change their minds at any point about being involved. Interviews will be taped and transcribed, but if participants prefer not to be taped then field notes will be used instead. Participants will be offered access to the field notes, interview transcriptions of their interviews, or observation sheets should they wish it. Again, where methods of data collection or analysis are adapted and developed, notes of ethical considerations and the approaches taken to them will be kept in the research journal and discussion of ethical issues with the PhD supervisors will continue throughout the project.

Give details of any other ethical issues which may arise from this project (e.g. secure storage of videos/recorded interviews/photos/completed questionnaires or special arrangements made for participants with special needs etc.):

Interviews will be kept on a password-protected computer and backed up on a removable storage device kept locked in NC139, along with any other confidential information such as IEPs, questionnaires or other data.

Give details of any exceptional factors, which may raise ethical issues (e.g. potential political or ideological conflicts which may pose danger or harm to participants):

This form should now be printed out, signed by you below and sent to your mentor to sign. Your Mentor will forward this document to the School's Research Support Office for the Chair of the School's Ethics Committee to countersign. A unique approval reference will be added and this certificate will be returned to you

Approval is requested for the period:

From: _____ **to:** _____

by (name of principle investigator): _____

Signature _____ Date _____
(principle investigator)

Name of Mentor: _____

Mentor declaration. *I am satisfied that the planned research procedures as described to me are ethical.*

Signed (mentor)..... **Date**
...../...../ 200....

School Ethics Committee approval reference:.....

Signature _____ Date _____
(Chair of School Ethics Committee)

Appendix 6: Example of coding process

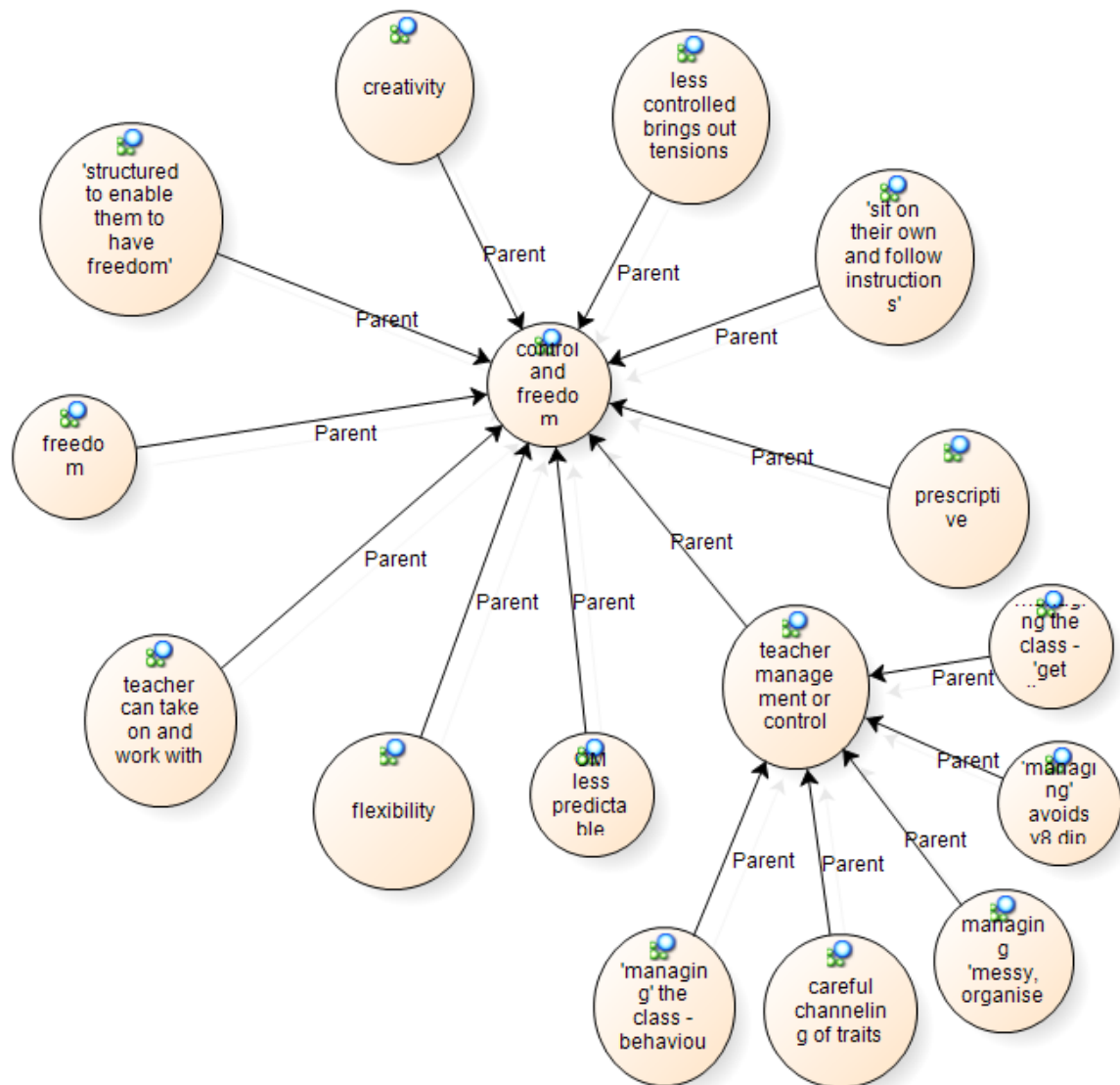
Interview transcript	Codes	Labels	Theoretical codes
LH: So this is Declan, Head of Year 7 and 8, OM teacher, general...			
WB: Dogsbody! [both laugh]			
LH: What I'm basically asking you about is your perception as a teacher of opening Minds and I know you were heavily involved in the planning of it...			
WB: Yep, yep.			
LH: So basically an impression of how you think it's going and what you think the advantages are, the disadvantages, that kind of stuff to kick off, if that's OK.			
WB: OK. Erm. I mean I...I think looking at the current year 8, it's an interesting year group because its 9 tutor groups: it's the biggest intake we've ever had. Its 60% boys and it was really interesting, it would have been great if we could have taken one of the three populations that makes up Year 8 and had a control and said, OK, they're not going to do opening minds. Because I think there was a general kind of consensus amongst staff, it was almost a bit like Chinese whispers, that they're a very confident year group anyway, they're very mouthy and chatty, and is opening minds what they need? Because its giving them more confidence, they're having to verbalise things, they're having to do a lot of independent work in groups, and actually we're kind of boosting one of their particular traits which we think needs...careful channelling(!).	<p>Large intake; mostly boys</p> <p>Impact of OM?</p> <p>Mouthy=bad</p> <p>Confident students don't need OM</p> <p>Careful channelling of traits</p>	<p>Characterising a group</p> <p>Opening Mouths</p> <p>Class management by teacher</p>	<p>Complexity Reduction</p>

<p>[LH laughs]. So it was quite...it was quite interesting seeing that happening. But I do think, and this is anecdotal, but talking to maybe practical subjects like Drama or PE... I remember the Head of PE, [Jill] last year saying, she'd set up a task where it was how are we going to; it was about strategies for sport, what are our defence strategies going to be, what are our offense strategies going to be? And she said in the past, year 7 groups had always fizzled out after 10 minutes and then they went off and played the game. And she said she set it up with the group last year when they were well into Opening Minds and it took them a whole double lesson. And they were just talking about strategies and it wasn't that they were arguing, it was just that they had so many ideas. And she, well obviously that's only anecdotal but she was really impressed and she felt it was, she'd taught it for 10 years and it was the clearest example of where they were able to, and willing to communicate. And some of the quieter ones were all willing to chip in. And I've, there were various bits of anecdotal evidence like that from Drama as well, which I found encouraging. Erm...I think the danger for me was that I come from a humanities background, alot of it is about looking at, you know the Asian Tsunami and getting kids to think about things and getting them to make films and presentations, we were doing that anyway. And I felt concerned that</p>	<p>OM helps students' discussion and communication</p> <p>Boosts quiet students' confidence</p> <p>OM not different to humanities</p> <p>More confident to experiment in OM after teaching it before "Go off at a tangent"</p>	<p>OM develops life skills (argumentation)</p> <p>OM needs to be different/innovative</p>	<p>Emergence (surprising)</p> <p>Emergent – teacher off at a tangent</p>
--	--	---	--

<p>OM wasn't just like, a good humanities lesson or a good lesson that you would get anywhere, already. I think the fact that the team has pretty much stayed the same and we know the schemes of work now has been good, because we were all kind of...clinging on to the framework that we created last year and we did some really good things. But I think this year we've been more willing to go off at a tangent. So when I had a...I mean I've got a lad this year in my tutor group, who has quite a lot of issues. And when we had a really bad day when he blew up and somebody had provoked him, and he got very grumpy very publicly and shouted and ranted and raved, we were able to spend a whole lesson, 'open minds style' kind of looking for solutions and what were we going to do about this and how were we going to support [Ross] and how was [Ross] going to cope with the others. And we used our CLIPS and kind of tried to do a bit of problem-solving. And I perhaps wouldn't have had the confidence to do that. As a teacher I would have been fine but, I was so concerned about getting through the content that we had created and we were all quite proud of it. (LH: yeah) Erm, and I think...So that's one concern for me that, for me as a teacher I quite like going off on a bit of a tangent and telling a story and getting the kids involved and being a bit dramatic. And now we kind of have got our schemes of work fairly well sorted, I think if you're confident</p>	<p>OM about working as a team to solve problems Teacher confidence to use time differently</p> <p>Need to get through criteria</p>	<p>Interactions in classroom</p> <p>Abandon planned lesson</p> <p>Meet objectives</p>	<p>Mechanistic (concern to get through content in OM)</p>
--	--	---	---

as a teacher, there might be a danger that you stray too far from the content and we do need to get through all those criteria.			
---	--	--	--

Appendix 7: Sketch of data



Appendix 8: Coding Manual

Code Label	Definition	Description
Mechanistic Change {linked to curriculum development as a sub-code of mechanistic change}	A change in a system that is predictable based on the immediate past.	Identified in descriptions by participants, or observations in field notes, where change is described but in familiar terms of reference; a 'logical' development based on past performance, or where cause and effect are apparently linked by the participants.
Socialisation {linked to mechanistic change}	An 'end' or purpose of schooling that is about ensuring students are able to act appropriately in social settings.	Participants discussions of what the purpose of a lesson or activity might be, or actions that are oriented towards these particular goals...
Enculturation {linked to mechanistic change}	An 'end' or purpose of schooling that is about ensuring students are able to 'fit in' with the culture of a particular discipline, the culture of the school or wider UK culture.	Participants discussions of what the purpose of a lesson or activity might be, or actions that are oriented towards these particular goals...
Qualification {linked to mechanistic change}	An 'end' or purpose of schooling that is about ensuring pupils get the required qualifications to be able to succeed in the future in particular ways.	Participants discussions of what the purpose of a lesson or activity might be, or actions that are oriented towards these particular goals...
Curriculum Development	Concerns changes to the curriculum that are developed according to familiar norms and systems; ends-based change.	Changes to the curriculum that maintain attributes of preceding curriculum system, such as learning objectives, and assessment goals and structures.
Curriculum Emergence {an example of temporal emergence}	Concerns changes to the curriculum that are not a continuation of the normal trajectory, but are unusual or unexpected; open-ended change.	Changes to the curriculum that go beyond the usual or preceding curriculum system in terms of content, structures or activities. For example, differing classroom settings than the tutor group of thirty students in the same year, or move away from particular content.
Temporal emergence {curriculum emergence label is a particular example of this}	General label for emergent phenomena – phenomena that are novel and unpredictable based on preceding events, patterns and structures. Emergence within the curriculum is an example of temporal emergence and sub-code for this category. <i>Emergent meaning</i> is another potential sub-code for this category drawn from O&B, as is <i>emergent subjectivity</i> . Anticipate sub-codes to emerge labelling particular types of temporal emergence that appear in the data.	Actions, Phenomena, Structures or Materials that emerge in an open-ended and unpredictable way. This may appear in the data as a description of such an event by a participant, or an observation in a lesson.

<p>Spatial Emergence/Self-organisation</p> <p>{links to levels of organisation label – emergent organisation labelled at a new level}</p>	<p>Appearance of groupings or structural relations that are not imposed from a position of higher authority</p>	<p>Interactions between elements within a system that develops freely, without constraint from authority. For example, students working together without being assigned in groups by a teacher, or teachers sharing ideas and resources through informal channels.</p>
<p>'Levels' of organisation</p> <p>{links to spatial emergence label – new levels develop as a result of spatial emergence}</p>	<p>CT allows research of phenomena to focus on a range of levels of emergent complex organisation that are able to interact with each other. This code highlights where the focus of a particular piece of data is at a particular organisational level – individual, group, class – and may include interaction with material as well as social.</p> <p>Important that this is not simply a way of simplifying wholes into parts. A higher level of organisation is more than the sum of its parts, and to be labelled as such needs to demonstrate emergent properties that is greater than the sum of its parts.</p> <p>Anticipate sub-codes to emerge labelling particular organisational levels that appear in the data.</p>	<p>Examples of levels of organisation might include individuals, groups within a class (e.g friendship groups) and whole classes.</p>
<p>Complexity Reduction</p> <p>{links to structure label}</p>	<p>The closing down of possibilities for action through time or space, or through reducing recursivity of the system by constraining language used.</p> <p>Anticipate a number of sub-codes developing during analysis labelling particular systems of complexity reduction operating in the system.</p> <p>Could potentially apply codes of 'prospective complexity reduction' and 'retrospective complexity reduction' from Biesta's work, using perception discussed in t.f. chapter that this cannot occur across a point of 'emergence' and only within a period of mechanistic change.</p>	<p>Imposition of structures or time scales that limit possible actions. CR examples in education discussed in literature as timetables, task structures, assessment objectives.</p>
<p>Subversion of Complexity Reduction</p>	<p>Working within limits of reduced complexity to find alternative</p>	<p>Examples might include students put in groups by teacher</p>

{links to temporal and spatial emergence labels}	novel ways to act.	subverting this through alternative interactions with others.
Far-from Equilibrium Conditions	Labelling conditions in the system where it is operating away from the usual equilibrium state, due to the introduction of some new 'environmental' conditions	This label could be identified if the participants describe a situation where the circumstances in which they find themselves are different from the usual – for example, a demand to respond to a change in the curriculum environment created by the government.
Equilibrium Conditions {linked to mechanistic change – and opposed to far-from equilibrium conditions linked to emergence}	In contrast to far-from-equilibrium conditions as described above. System is operating in its usual state; change is mechanistic rather than emergent.	Description of an environmental state rather than a particular change, action or event, but linked to mechanistic change and not emergence.
Agency	Defined as the capacity to act. In complexity theory, agents may be individual people, but may also be group. Discussed in framework as relational – capacity to act in relation to others.	Identified through observed or reported action.
Structure	A broad term that will be separated out during open coding – referring to organisational or social structures and the materials and tools that support them	Identified through reference to particular elements of organisation such as management structures within a school, classroom structures etc.
Reflexivity/Reflection	Again, in complexity theory, reflection not seen as solely the preserve of the individual – group reflection/reflexivity also possible.	Identified directly in interviews, by description of reflective action and in lesson observations where reflection is explicit (or implicit in a change of behaviour?)
Identity/subjectivity – self-described	Literature discusses identity in terms of how an individual or social group see themselves. In t.f, focus is on identity in relation to others.	Recognised in participants' description of themselves, within their social setting.
Identity – described by others	Literature discusses identity in terms of an individual or group's perception of how others see them	
Identity development	A change in identity that is linked to mechanistic goals of schooling – such as socialisation. Of particular interest is change in identity in relation to change in the curriculum for both teachers and students.	
Relational Power	Linked in theory to the concept of relational agency and social structure. Rather than focussing on power held by individuals, the focus based on the t.f is in the network of power relations, and	Recognised in interviews and observations through particular characteristics of relationships described or seen. Open coding in relation to this concept may identify 'emergently responsive' or

	this is therefore likely to link to interactions identified in the texts.	'complexity reduced' power relationships?
Interactions	This broad label concerns interactions between participants, and between participants and 'things', and between groups of participants.	