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Developing creativity within primary science teaching. What does it look like and how can classroom interactions augment the process?

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Abstract

This study contributes to the understanding of what it is that primary school teachers do (or could do) when engaging with their pupils to nurture creativity in science lessons. The research consists of a series of observations (i.e. three related cases), post-observational interviews with teachers concerning their practice and a survey of over 100 practising primary teachers. Lesson observations were examined through various analytical tools, which informed the generation of graphical representations to illustrate the teacher's practices. The interview and survey data were analysed using frameworks developed from Ann Oliver's ten ways to make science teaching creative and Dylan Wiliam's five key formative assessment strategies. Interview data was also examined inductively to explore how far self-reports of creativity reflected observed practices.

The deductive findings from the survey and interview data suggested teachers believed that they taught science through the child's everyday experiences. This reportedly provided children with opportunities to independently observe scientific phenomena from alternate perspectives. However, the findings from the observations, and the inductive examination of the interviews illuminated how the teacher's encouragement of agency-in-learning supported development of creativity. A wide range of pedagogic approaches adopted by teachers were shown to elicit emergent creativity-in-learning. To reify the nature of creative and critical explorations through the teacher-child verbal exchanges, dialogue was analysed by adopting a more comprehensive analytical framework, developed from Mercer's three types of talk and Alexander's lesser-known five patterns of teacher talk. The results of these analyses were reflectively scrutinised to explore how formative assessment strategies could support the development of creativity.

Ultimately, it is anticipated that the findings from this study could inform the ways that researchers and practitioners consider and reflect upon the nature of creative teaching, the ways that it differs from creativity-in-learning and the influence(s) that formative assessment might bring to bear.

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Chapter 1

Introduction

1.1 Rationale behind the study

Throughout this study my work has been that of a participant observer. My research approach and analytical frameworks have been informed by my perspective as a classroom-assistant-turned-educational-researcher. It was through my active and participatory work as a teaching assistant in various primary schools, as well as my reflective reading of relevant literature, that informed the way this study reflexively evolved.

By observing primary school science lessons as a teaching assistant, I initially construed how a teacher could be creative. For example, I witnessed teachers demonstrating WOW experiments (Feasey, 2005), involving startling phenomena such as floating eggs in water (by adding salt) and demonstrating how air from a hair dryer can be used to suspend a ping-pong ball in mid-air. Whilst these teacher-led presentations can (and have) observably raised exclamations of 'WOW!' and even some 'I wonder' questions, I, the researcher, was curious and wondered what would have happened if the children had been provided with the chance to explore and investigate for themselves why and how these things happened. Given open exploratory opportunities for learning, would there have been more opportunities for the children to independently devise their own personalised investigations and/or understandings?

I began to realise that there were two polar aspects resulting in creativity in the primary science classroom. One was teacher-led the other child-initiated. This prompted me to examine the literature, and the term 'creative teaching' (NACCCE, 1999; Davies, 2011). This practice consists of two pedagogical approaches: one is related to the teacher and their ability to communicate science in an imaginative and innovative way, referred to by the NACCCE as teaching creatively (TC), and the other relates to teaching that enables the pupils to develop and express their own creativity, this is known as teaching for creativity (T4C) (Davies, 2011). Whilst Craft (2005) believed it was important to recognise the source of creative effort, i.e. whether it emerges from the teacher or learner, she also acknowledged that it was imperative not to differentiate falsely between them, because dichotomising the choice between teacher and child ownership would '…be unhelpful to the development of creativity in education', for when teachers teach creatively (just as the teacher above had by performing her wow experiments) children can also, at the same time be stimulated (*ibid:*43).

It was this consideration that provided me with the initial incentive and motivation to carry out this study.

Through further reading and reflective discussion with my supervisors, I considered observations I made as a classroom assistant and began to formulate additional questions, such as: How would teachers describe creativity? Do the teachers' creative endeavours affect the children's own developing expressions of creativity? What is creativity-in-learning and what does it look like? To what extent do both TC and T4C support the development of creativity-in-learning? How (or do) the statutory requirements of the Science National Curricula affect the development of creative expression? What do teachers, in actuality, do to augment and foster creativity during their science lessons and how does this compare to their espoused views? And finally, would I be able to suggest additional ways (e.g. through the verbal interactions taking place between teacher and pupils) in which the teacher's practices could be adapted to enable the children's creativity to be reified (i.e. that is to be made more explicit or concrete)?

To provide further stimulus, and to reflect upon the above questions, I initially turned to the Creative Little Scientist Project (CLSP). This was a pan-European research project which was described, by Glauert and Manches (2013), as one which examined the practices of early years' science teachers to provide insights into how children's creativity can be fostered. Within this project Glauert and Manches postulated that when considering creative teaching, '…it is important to move beyond simple associations of creativity with positive dimensions of teaching, [to]…understand how specific approaches can help children' (*ibid*:35). It was by taking this advice to heart that I began to recognise that answering my expanding list of questions was going to be more complicated than simply associating observed or reported creativity with two component parts of creative teaching (TC and T4C). That is, I acknowledged that the reification of creativity through teachers' practice would be a complex, multifaceted process, for not only would it involve the teacher's subjective view of creativity, but also their diverse skills and the manner in which they chose to employ their numerous different strategies to afford the children their own creative opportunities (Craft, 2005).

The timely nature of this study became clear because it was initially developed when creative teaching was being challenged by the Department for Education (Gove 2013a, 2013b). Gove (2013b) believed that this pedagogical approach contained 'an anti-knowledge ideology' and he went on to advocate a 'knowledge-rich curriculum as the key to educational success' (Gove, 2013a). Interestingly, and contrasting with these views, research into a creative teaching approach has supported the use of authoritative (direct) information within its practice. For example, in Yeo and Tan's (2010) study students (aged 14-15) underwent a problem based learning activity and found that the utilisation of authoritative sources of information was not counterproductive to their ability to think creatively. This aptitude was described, by Yeo and Tan, as a process akin to Finke *et al's* (1996) cognitive model of creativity. That is, these external (directive) tools were employed successfully for informing new, fresh cycles of developing ideas indicating factual knowledge was required to foster the development of innovation and should not be being pushed aside for the sake of a creative approach (Christodolou, 2014), contrary to Gove's (2013a; 2013b) reasoning.

1.2 The objectives of my study outlined

Whilst I recognised the complex nature of developing creativity in primary school science lessons, and acknowledged the importance of scientific knowledge within creative teaching, my initial objective at the outset of this research study was to attempt to capture the distinctive features of creative practice. The first step in designing this framework began by examining and considering all the questions asked by a teacher during a single science lesson, using a framework adapted from Wragg and Brown (2001). Then, through further observations and by considering my own anthropological reflections, I developed an observational framework with the Flanders' Interaction Analysis Categories or FIAC (Flanders, 1970) in mind. Reflexively, I have accepted that at this point of my study, as a former professional scientist, I was seeking an overly positivist stance. That is, ontologically I was seeking a systematic framework which made a complex subject simpler and more manageable (O'Leary. 2014). However, as I continually reflected upon my research, a transition between two paradigms began (shifting from positivist to a more interpretivist stance).

This transition continued to develop as I sought to quantify my observational findings through three theoretical lenses: encouraging autonomy, taking risks and establishing when teacher-child interactions occurred. I subsequently re-worked the data into graphical illustrations. These proved to be useful visual illustrations of the ways individual teachers developed creativity throughout a complete science lesson, from start to finish. However, I realised that I was still epistemologically looking for human behaviour that could be governed by a set of rules (Edirisingha, 2012). Reflexively considering the nature of this developing observational framework through my emerging interpretative paradigm, I realised that there were a number of further ways that a teacher could promote creativity within the primary science classroom. I realised, too, that the development of creativity also involved the affordances that were made available to the learners during the science lesson. It was during this phase of the study that I was influenced by the work of Mercer and Hodgkinson (2008) and Mortimer *et al* (2015); they had each successfully captured (in the written form and visually) the social and physical interactions that occurred between teacher and child throughout specified periods of the school day. By reflecting upon these ways of displaying observational data, I endeavoured to generate an events map for each observation which would visually illustrate the various activities engaged in and the teacher's and/or pupils' actions throughout the science lesson. Additionally, after taking council from Bird's (2011) doctoral thesis, I also opted to display five choice verbal exchanges between teacher and pupil (i.e. speech-acts) within these maps of events. These interactions were individually examined through a fresh analytical framework, conceptualised through both Alexander's (2008) five patterns of (teacher-child) talk and Mercer's (2008) three types of child-child interactions. It was intended that the examination of these speech-acts would clarify how the reciprocal aspects of scientific learning were (or can be) assessed within a science lesson, whilst also keeping in mind how the natural conversation would/could simultaneously reify the pupil's developing creativity (these results were also represented visually).

As well as generating three different graphical illustrations to represent three particular aspects of the way a teacher could promote creativity in a science lesson, I also wanted to explore how the observed teachers perceived they augmented creativity through their own self-reflections. This was undertaken in light of a study by Johnston (2007) that indicated that there was little correlation between the teachers' espoused views of their practices and what was, in reality (from an observer's perspective), occurring in the classroom. To explore whether this finding echoed my own observations, I followed an approach adopted by Craft *et al* (2014) whereby I carried out post-observational interviews with each of my observed teachers. The questions the teachers were invited to answer were adapted from Craft *et al's* study and were specifically designed to find out how the teachers believed they nurtured (and assessed) creativity in their science classroom. These responses were then inductively contrasted with the results from the observations to explore how far practice reflected the teacher's reported perspectives.

These eleven interview questions were also triangulated with the survey (of 101 responses) so that I could cross-reference both sets of data. This survey was designed to gain further insights into the nature and extent to which numerous other teachers reportedly believed creativity emerged in their primary science classrooms through their practices. This cross-examination, between survey data and interview responses, was achieved by deductively applying an analytical framework to review creative teaching and consider assessment of creativity to both data-sets. The first framework was adapted from Oliver's (2006) ten ways to make science teaching creative which provided a platform from which to understand what teachers believed they were doing to augment the development of creativity in their science lesson(s). The second framework, conceptualised with Wiliam's (2011) five key strategies of formative assessment in mind, was originally designed to discern, from the teachers' descriptions of formative assessment-in-practice, how they met the formative learning needs of the pupils. Through the second framework it was intended that I could consider whether there was enough detail in the teacher's responses to indicate whether or not they were supporting creativity-in-learning through formative assessment strategies.

Scott (1996) noted that triangulating different methods of data collection allows for discrepancies to be pursued, but it was Mitchell (2006) who stated that this approach also provided the optimum conditions for illuminating insights and making previously unseen connections visible. It was therefore hoped that the above cross-examination of the observations, interviews and survey data would bring a richer deeper level of interpretive understanding to my research.

1.3 Outline of chapters

In this introduction I have presented the central focus of this thesis, that is I am seeking to gain insights into 'what a teacher does to develop and assess creativity in the primary science classroom' and I have also briefly outlined the methods I employed to achieve these ends. I will now describe what can be found within the main body of my doctoral thesis.

To contextualise the above objectives (and methods of data analysis), as described in section 1.2, chapters 2-4 of this thesis, the literature review, contain the theoretical frameworks that informed my study. Chapter 2, section A, situates the current definitions of creativity within the primary school classroom and considers how policy imperatives can affect its development. I also examine innovation and scientific endeavour through the qualities of past historical eminent scientists. Section B then provides a platform to better understand how creativity can be understood through the teachers' practices. By considering these viewpoints I was able to discern the multifaceted aspects of a creative teaching approach. This led onto suggesting the conditions required to augment and deliver opportunities to stimulate creativity-in-science through both TC and T4C. In the third chapter of the literature review, I briefly examine how primary school teachers currently formatively assess learning in science (section C). Following this, in section D, I contemplate how (or if) creativity-in-learning might be illustrated through current academic theories on assessment.

The fourth chapter conceptualises what creativity-in-learning could look like in the primary science classroom.

The fifth chapter is where I justify my methodology, and the methodological approach undertaken is illustrated through my own anthropological learning journey. That is, I reflect upon my own observations and contemplatively consider any relevant literature. It is this approach that has contributed to the development of data collection methods and all my analytical research tools.

The next three chapters (6-9) contain the results of my examination of the data collected. This data was gathered through three different methods, namely through a survey, observations and post-observational interviews. All four result chapters are briefly outlined below.

The sixth chapter examines the espoused views of over a hundred teachers, which were garnered from survey questions and related to how they nurtured and assessed creativity through their practice. Following this, in chapter 7, I endeavoured to illuminate where and how creativity was evident by examining three related cases, through three different means, i.e. through the analysis of the teachers' questions, via an observational schema and by generating a timeline of mapped events. Chapter 8 was essentially a continuation of chapter 7, and was comprised of reflective analyses of five speech-acts from each of the three observations. These were examined to clarify how the exchanges may or may not have reified creativity. Finally, in chapter 9, I deliberate upon three teachers' responses to post-observational interview questions.

My penultimate chapter (the discussion) is in two parts. Initially I reflectively consider my methodological approach and the methods (research tools and analytical frameworks) employed to answer my research questions. In the second section I directly respond to my four research questions. Finally, in the eleventh chapter I draw my conclusions and make recommendations for initial and further teacher training (i.e. pre-service and continued professional development) in primary science and consider possible future research studies.

Having outlined this research project in the introduction, I begin my thesis by reflectively considering a fascinating illustration of a child's imaginings. This seminal moment, which I was fortunate to witness, occurred within the first few days of my attempts to adopt a classroom assistant-researcher standpoint.

Chapter 2

The literature review: reviewing the nature of creativity

Three years ago a foundation stage child called me over to have a look at a spider's web situated on a bush. *'Look! Look!'* she cried, '*I know why that spider is there!*'. She pointed to the arachnid who had positioned itself in the centre of its web. I was intrigued. I asked her *'why?'*. As a former scientist I expected her to state how it was the ideal position for small insects to be blown into the arachnid's trap. However, her index finger slowly but steadily moved from the spider and pointed rigidly to a small red berry positioned slightly to the left of the web. She turned her gaze towards mine and looked me directly in the eye. She confidently stated, '*Because that's its food and he can get to it easily*'. I was staggered, a four year olds imagination had just offered a plausible suggestion that did not conform to what I, as a trained scientist knew about the behaviour of spiders. '*Wow!' I exclaimed,* I paused for a few seconds to collect my thoughts before asking, *'So there's no other reason for the spider to be there?*'. The girl continued to look directly in my eyes and self-assuredly stated, *'No!'*. This was, as far as the girl was concerned, the end of our conversation. She marked this by leaping up into the air spinning around and skipping joyfully away.

I often think back to this brief but informative incident and reflect upon how this early years learner had developed her own creative explanation, which proved to be quite an original idea to that currently held by scientists. It is with this in mind that I now recognise how unfettered openings can allow children to articulate their 'own' individual perspectives. I can also begin to appreciate how these 'creative' beginnings encourage imagination. The challenge for teachers therefore would be to provide the opportunities for children to confidently assess the evidence and construe their own unique explanations (which in the future may enable them to generate original explanations or even solutions to the unique problems they face). It is the nature of these creative engagements, during primary school science lessons which has become the key focus of my thesis.

However, a review of leading authorities has revealed that there are a vast number of views relating to the nature of creativity (McGregor, 2007). These have interpreted creativity as a process that involves: generating ideas and possibilities, developing new perceptions, fresh ways of understanding and producing something that is novel (or unexpected). All five of these characteristics can arguably be facets that can be integrated into the story above. After all, the girl generated the idea (or the possibility) of the spider setting up home near its food source. In her mind this led to a new insight (or understanding) that was novel (and especially for me, the trained scientist, unexpected). After further consideration it is my opinion that these views of creativity are descriptions that relate to a multifaceted complex process. Thus during this literature review I will critically consider a range of views to construct a ‘definition’ which can inform this thesis.

Whilst pursuing this more dynamic definition of creativity I will also seek to understand how, where and when creativity emerges in learning through a teacher’s practice. I will subsequently consider how it might be ‘captured’, reified or brought into existence to enable a teacher to assess it.

2.1 Literature review: the strategy

A systematic approach was taken through interrogating three databases, Zetoc, Web of Science and ERIC. The keywords and phrases utilised within these searches were: primary science, science education, creativity, creative teaching, teaching creatively, teaching for creativity, creative learning, assessment for learning, assessment of learning, formative assessment and summative assessment. The same databases also had alerts set up for specific authors, these included, Alexander, Beghetto, Black, Chin, Claxton, Craft, Cremin, Davies, Earle, Feasey, Glauert, Glăveanu, Hargreaves, Harlen, Harrison, Kamphylis, Kaufman, Manches, McGregor, Naylor, Runco, Stylianidou, Oliver, Turner and Wiliam. Individual journals were also selected because of their relevance to the project. These included the ‘*British Journal of Educational Studies*’; ‘*Cambridge Journal of Education’; ‘Creativity Research Journal’;* ‘*Education 3-13*’; ‘*Journal of Emergent Science*’; ‘*School Science Review*’; *and the ‘ International Journal of Science Education*’. I also followed up references of articles when I found there citations and/or quotations useful.

This logical approach enabled me to comprehensively access literature which provided the background, context and focus for the research.

2.2 Creativity and policy expectations in schools

In section A I will critically scrutinise the varying definitions of creativity found within the learning environment and the primary school setting. I will follow this with a discussion that identifies how past scientists have been creative. Additionally I will also deliberate upon the nature of creativity as reflected through, and motivated by, policy imperatives.

SECTION A

Throughout section A I will be periodically revise my personal definition of creativity as I envisage it through the literature being scrutinised. This is not an attempt to reify (or make static) this concept but an endeavour to conceptualise its nature within the primary school science lesson.

2.2-A.1 Current understandings about creativity-in-learning

To be able to explain creativity-in-learning the challenge is to elucidate what it is. A lack of a clear definition may lead to a variety of interpretations and this could be one reason why teachers are not clear about 'what' it is or the 'best way' to support it (Kamphylis *et al*, 2009). For example, how can a teacher or a child take ownership of something, or be expected to have the motivation to implement it, when they are not able to conceptualise how to apply its abstract nature? Thus, if they were able to define and recognise creativity-in-learning, perhaps this would provide a support from which they would be able to augment and foster its development. However, this is a difficult process especially considering the multitude of definitions of creativity that have been offered in various pieces of literature. For example Welch (1980), cited in Isaken, (1987:9) reviewed twenty-two descriptions of creativity, whilst Rhodes reported that he had collected over fifty-six (Rhodes, 1961), he went on to say that whilst numerous these definitions were not 'mutually exclusive' (*ibid*:307) because:

> '…They overlap and intertwine. When analysed, as through a prism, the content of the definitions form four strands. Each strand has a unique identity academically, but only in unity do the four strands operate functionally' (*ibid*:307).

The four strands interacting 'in unity' were labeled 'the four P's of creativity'. They were:

1) 'the person' - the 'personality, intellect, temperament, physique, traits, habits, attitudes, self-concept, value systems, defense mechanisms, and behaviour' (*ibid*:307)
2) 'the process' - which '…applies to motivation, perception, learning, thinking, and communicating' (*ibid*:308),
3) 'the product' - which is when '… a thought [an idea]…has been communicated to other people in the form of words, paint, clay, metal, stone, fabric, or other material' (*ibid*:309) and

4) ‘the press’ - which constitutes ‘…the relationship between human beings and their environment’ (ibid:308) because ‘no-one can perceive a person living or operating in a vacuum’ (*ibid*:305).

However, as Isaken (1987:10) pointed out, this approach towards creativity, which appeared to incorporate all human beings regardless of age, or their perceived ability, kept the definition so general it was not directly useful to apply in educational settings.

2.2-A.2 Current definitions of creativity-in-learning

To aid in the description of the dynamic entity that is creativity I shall illustrate it from two alternative perspectives. They are: the individualist viewpoint where ‘…creativity is a new mental combination that is expressed in the world’ (Sawyer, 2012:7). This could be indicative of a fresh idea, a new thought or a combination of these imaginings. There is also the sociocultural standpoint where ‘…creativity is the generation of a product that is judged to be novel and also appropriate, useful, or valuable by a suitable knowledgeable social group’ (*ibid*:8). The second perspective is very different from the first, for it depends upon the views of others and their interpretations of the features of the end product. If these definitions were placed into the school environment such as, the little girl talking about the spider and the berry, then from an individualist outlook this situation would have been classed as creative. From a sociocultural position (e.g. judged from within the enculturation of an academic scientific community) her idea (her product) may not be recognised as so socially valuable. The sociocultural approach to creativity also incorporates two characteristics that have been considered the consensus opinion regarding what creativity is. These features are: ‘originality and value’ (Mayer, 1999:450). Many educational researchers recognise this (Best and Thomas, 2007:27; Kaufman & Baer, 2004:4; Boden, 2001:95). Thus, if we consider the story of the girl and the berry these two characteristics may be considered inappropriate in the confines of a school science lesson. Upon first examining the actual definitions offered within my specific field of study, primary school science, similar features had been offered. For example Kampylis *et al* (2009) offered the definition below (the two comparable characteristics are *italicised*).

> ‘We call creativity the activity (both mental and physical) that occurs in a specific time-space, social and cultural framework and leads to a tangible or intangible outcome(s) that is *original, useful*, ethical and desirable, at least to the creator(s)’ (*ibid*:18).

Here Kamphylis *et al*, admits to adopting a social and cultural framework. Perhaps then, an argument could be made that this description is an inappropriate application of the term creativity within a primary school setting.

The Creative Little Scientists Project (CLSP) generated a definition that was established to promote and develop creativity within the early years science classroom. The CLSP stated that creativity can be evidenced when children '…generate and evaluate ideas and strategies…' (Stylianidou *et al*, 2014:2) either '…as an individual or community, and reason critically between these' (Glauert and Manches, 2013:59-60). It could be argued that this is an individualist stance because the two characteristics of creativity, 'originality and usefulness', are not immediately evident. The CLSP however, also discussed creativity in terms of producing useful novel ideas and/or thoughts, and inspiring originality through curiosity-driven activities (Cremin *et al*, 2013:20). This links into Craft's (2001) everyday 'little-c' creativity where the children actively explored the notion of 'possibility thinking' whilst engaging with everyday challenges. A specific example of this type of creative thinking from my own experience would be observing a year 6 class exploring how to create a series circuit. The children were given all the wires, bulbs and batteries they needed and told to work out how to light three bulbs in a series. Ten minutes into this activity I discovered a girl rubbing a nine volt battery on the carpet. I asked her what she was doing and she confidently stated *'The battery is flat. I'm charging it up with static electricity'*. The scientist in me knew this was incorrect however, this girl was not only possibility thinking whilst tackling this everyday problem, she was also drawing on her previous personalised experiences with the scientific phenomenon. Runco (2003:318) linked this type of everyday problem solving to the ordinary folk as it involved '… the construction of new meaning', i.e. the girl would have eventually discovered (through further experimentation) that batteries could not be charged through static electricity. This activity Runco stated '…may sound contrary to [sociocultural] theories of creativity [such as Sawyer's (2012) philosophy] which emphasise originality and usefulness… [but] there is no incompatibility if you keep in mind that a personal construction will likely be original and useful to that one individual' (Runco, 2003:318). Thus the new 'mental combinations that are expressed in the world' (Sawyer, 2012:7) could be original and useful to the creator (i.e. the child) as long as the witness to their creativity (i.e. the teacher and peer group) appreciates and incorporates the child's own personalised expression of their reified understanding as part of their learning. Perhaps then, in the classroom it is the participants in the lesson that could become the suitable and knowledgeable social and cultural group from which to judge the child's product. It is through critically considering this that I have deliberated upon the following. In education, creativity can be developed by a teacher who appreciates the child's own ability to develop creative thoughts and ideas, both as an individual and socially with their peers. Thus individualist and sociocultural perspectives should arguably not be considered as mutually exclusive entities in the classroom.

2.2-A.3 Current understanding surrounding creative thinking in learning

Jeffrey and Craft (2004) stated that creativity could begin with the active intention of the teacher '…to develop young peoples' own creative thinking or behaviour' (*ibid*:1). Here Jeffrey and Craft have suggested that through the children immersing themselves in creative thinking the creativity-in-learning will seemingly develop from within the child. This approach appeared to take an individualist stance, but if a teacher is to develop creative thinking and/or behaviour through a sociocultural perspective then it is how the creativity develops through the child's interactions (actional and verbal) with other classroom participants (teacher and peers) that will also need to be considered. However, before we deliberate upon this we will need to establish what creative thinking is. McGregor (2015) has provided eight different interpretations to begin this process (see figure 2.1).

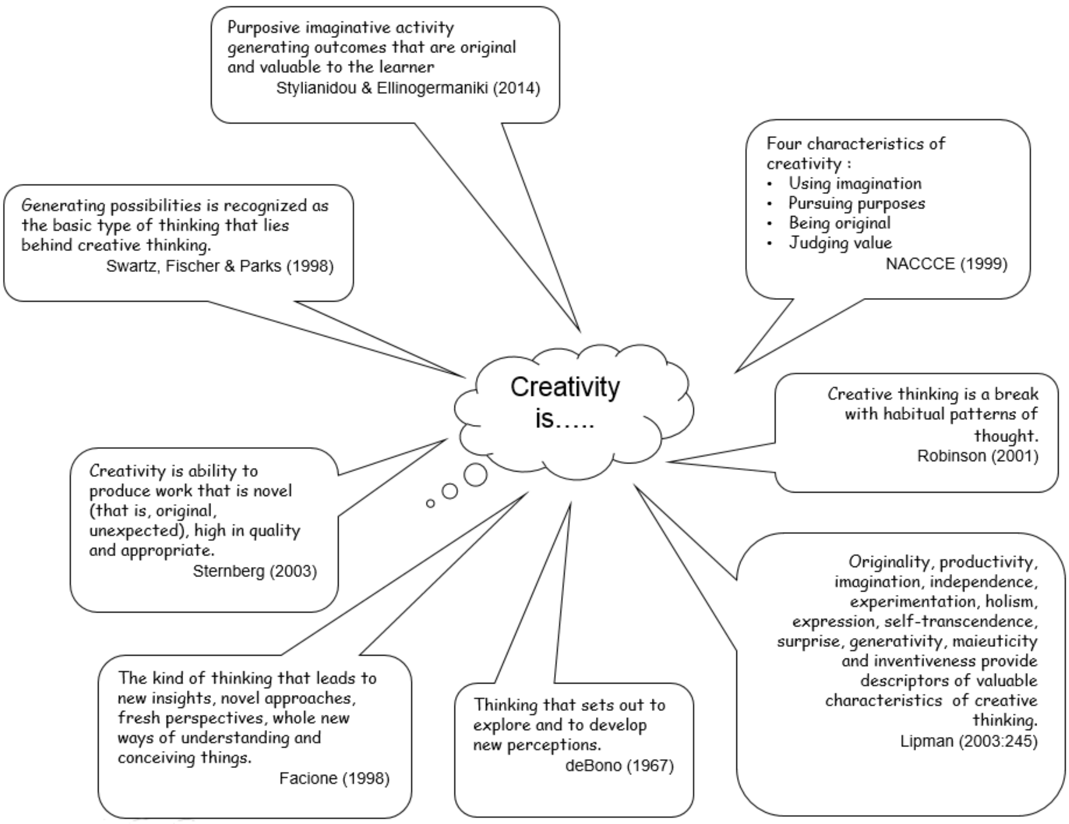


Figure 2. 1: Eight definitions of creative thinking (McGregor, 2015)

Through examining figure 2.1 I acknowledge the vast range of definitions relating to creative thinking. I also begin to understand how Welch and Rhodes, could have envisioned them intertwining. To appreciate these linked attributes I will further examine each description (using the referenced names only) and I will critically debate their merits and their worth by contrasting and relating them to each other and to other relevant literary writings in this field of study.

2.2-A.3.1 Originality and usefulness

Originality and value have been discussed previously (see section 2.2-A.2), but it is still important to review these to help to define creative thinking. The definitions on figure 2.1 have Stylianidou and Ellinogermaniki (2014), NACCCE (1999), Lipman (2003) and Sternberg (2003) all mentioning 'originality' and all but Sternberg refer to 'value'. Individual and sociocultural perspectives were previously debated, and any expressions of creativity were considered to be original and useful to the learner, as long as the teacher and peers judged the child's mental combinations through the creator's lenses. Perhaps then, an initial definition of creative thinking should be *the formation of ideas and concepts that are original and useful to their creator.*

2.2-A.3.2 Having a purpose

Stylianidou and Ellinogermaniki (2014) and the NACCCE (1999) also describe creative thinking as being purposeful on figure 2.1. However, Sternberg tempers this when he described 'having a purpose' as needing some form of context:

> '…[creativity] must always be defined in some context. If the creativity of an individual is always judged in a context, then it will help to understand how the context interacts with how people are judged. In particular what type of creative contributions can a person make within a given context?' (Sternberg, 2003:125).

Sternberg is highlighting, to me, how neither Stylianidou and Ellinogermaniki or the NACCCE have considered a criteria (or set purpose) from which to reveal creative thinking. Examples of set creative purposes could be illustrated through Sternberg's (2003:129) eight models of creativity. These are:

1) Replication: helping to keep the field of study where it is.

2) Redefinition: a change in perception, seeing the field from another viewpoint.
3) Forward Incrementation: Moving the field forward, in the direction it was originally heading.
4) Advance Forward Incrementation: Producing an idea ahead of its time.
5) Redirection: Moving the field into a new direction.
6) Reconstruction: Moving the field back into a previous state and then moving it into a different direction.
7) Reinitiation: Starting again from the beginning point due to not reaching a satisfactory conclusion.
8) Integration: Combining together two distinct ideas or ways of thinking.

Whilst these are arguably perceived through a more holistic view of creative thinking (i.e. they could be generalisable to child and/or adult expressions of creativity) they can also be placed into the boundaries of a science lesson. For example, the girl and her understanding of how a nine volt battery operates, could have potentially followed the reconstruction model to reconceptualise her idea to comprehend her misinterpretation of how electricity is stored in a battery. I was also involved in an interaction with a year 2 child who used the model of integration as a way to understand night and day. The girl imagined two people swapping places in a room and combined this distinct idea with the Earth's rotation around its axis in order for her to cognitively capture this scientific notion. The child was initially reticent to tell me her idea because she thought the analogy she had formed was *'silly'* (her words), thus she herself thought it was an unusual association between two disparate ideas. This integrative model is very similar to Robinson's (2001) definition of creative thinking where he described it as the '…break with habitual patterns of thought…[and these] creative insights often occur [by] making unusual connections, [and] seeing analogies between ideas that have not previously been related' (*ibid*:135).

Sawyer (2012) took Sternberg's eight models of creativity further and visualised creativity as shapeless, rather than a set of plotted and structured pathways. Sawyer suggested that 'truly transformative creativity…might even create an entirely new "search space" with a radically new topology and geography' (*ibid*:91). Thus setting a purpose when trying to develop creativity could be seen as contradictory, restrictive and even as an unproductive practice when considering all the numerous (and perhaps unforeseen) conduits creative thinking might unpredictably cultivate along the way. This rather nebulous nature of creativity is probably a more apt description of creative thinking than having a set purpose (and/or pathway) as this presupposes that these creative trajectories are linear, and pre-definable. Thus I can perceive of no valid reason to use the term purposefulness in a definition of creativity. However, I am able to currently visualise the numerous (if not infinite and as yet unknown) routes creative thinking may take. So my definition of creative thinking will now be *the formation of ideas and fresh concepts that are original and useful to their creator.*

2.2-A.3.3 Imagination

Imagination was another characteristic of creative thinking mentioned within the Stylianidou and Ellinogermaniki, (2014), NACCCE, (1999) and Lipmann (2003) definitions. However, Stylianidou and Ellinogermaniki's meaning, by their own admission, is drawn from the NACCCE report. They state the NACCCE's explanation of imagination does '…not translate well to the school system and thus…[is] not that useful for teachers' (*ibid*:7). Why they believe this to be the case is not explained, and despite this they still use the term (and its synonyms) ten times. I find myself having to return to the original NACCCE (1999) document to seek a more in depth explanation of the term. The NACCCE reports that an '[i]maginative activity is the process of generating something original: providing an alternative to the expected, the conventional, or the routine' (*ibid*:31). Therefore, it could be argued that the NACCCE envisages imagination as a way to enable an individual to see ideas afresh from a new perspective. This way of visualising creative thinking is not new, both de Bono (1967) and Facione (1998), cited by McGregor (2015), had previously described creative thinking as a way to conceive and explore new understandings (or ideas) from different standpoints (see figure 2.1). De Bono (1992:185) called this 'lateral thinking', however, this would only incorporate one of Sternberg's eight topologies (i.e. the redefining model) and does not capture any of the other seven pathways.

Lipman (2003:162) describes imagination as a way to envisage a world of possibilities. This is akin to Robinson's (2009) description when he stated that imagination had '…the power to release our minds from the immediate here and now…We are free to revisit the past, free to reframe the present, and free to anticipate a whole range of possible futures' (*ibid*:58). This generation of possibilities is also how Swartz, Parks and Fischer (1998) described creative thinking. It has also been linked with divergent thinking (McGregor, 2007:169; Sawyer, 2012:52). However, when this definition of imagination is involved with a creative process, according to Robinson (2009:12), it requires the individual to mentally and physically act. This physical action according to Robinson involves different stages. Sawyer (2012:88-90) described eight stages. They were:

1) finding a problem,
2) acquiring knowledge relevant to the problem,

3) gathering a broad range of potentially related information,
4) taking time off for incubation,
5) generating a large variety of ideas,
6) combining ideas in unexpected ways,
7) selecting the best ideas, applying relevant criteria and finally
8) externalising the idea using materials and representations.

It is only at the eighth stage where creative thinking becomes physically observable through the act of doing.

However, as I stated earlier (see section 2.2-A.3.2) transformative ideas, according to Sawyer (2012), may only occur within (or begin with) an amorphous 'search space', not through a linearised list of eight stages. Sawyer visualises this search space as a balloon expanding and filling with creative ideas, here all the possibilities are generated and pooled together. This initial stage is followed by convergent thinking which involves scrutiny of known information and data. According to Finke *et al* (1996), this ascribes to the Gleneplore model of creativity, which continues in iterative cycles (that is first you 'generate' ideas and then subsequently 'explore' or evaluate them). These cycles will continue and create preinventive structures until a final product/idea is reached (Finke *et al*, 1996). This iterative process, according to Robinson (2009:153), will include '…elaborating on the initial idea, testing and refining them and even rejecting them, in favour of others that emerge during this process'. Fisher (2001:13) labelled this process 'critico-creative' thinking. It is through this critico-creative practice that Robinson (2009) claims active learning can take place and the learner (and their peers) can form judgements on the preinventive structures and final products.

I believe this cyclic process (the Glenophore model) has synergies with Sawyer's eight stages. However, as I stated, these eight phases are linear whereas the search space is fluid. This suggests that the eight steps may not occur concurrently. For example, the girl with the nine volt battery found a problem (it was flat, step 1), then she combined her ideas (step 6) i.e. she believed that a static charge could generate an electrical potential within the battery, and then finally she externalised this by rubbing the battery on the carpet (step 8). Notice that she missed out steps 2, 3, 4, 5 and 7. After the realisation that this way of charging the battery could not work the girl could have, on her own, gathered further ideas (step 5), from here she could have critically scrutinised these ideas against a range of relevant knowledge (steps 2 and 3). Then she could have taken her time (step 4) and selected the best ideas (step 7) to resolve the situation. This theoretical example only serves to emphasise the mosaic and yet fluid-like routes creativity can take.

From the lengthy discussion above, imagination (i.e. the ability to see all possibilities through divergent thinking) contributes to creative thinking. However, because of the fluid nature of how the individual may interact with their ideas, it can only be considered to be one facet of creativity, and Swartz, Park and Fischer's (1998) definition of creative thinking (also found on figure 2.1), which only describes the generation of possibilities, is a limited perception of a much more multifaceted process. Following these conclusions I have developed my definition of creative thinking to now read as *the formation of all possibilities and fresh concepts that are original and useful to their creator.*

2.2-A.3.4 Maieutic thinking

Having critically examined most of the features of creative thinking found in figure 2.1 it is impossible to continue to ignore Lipman's (2003) twelve characteristics. However, even Lipman states that his list of twelve descriptors is incomplete '…there could be many more or many less' (*ibid*:247). Thus ownership of this apparently amorphous concept by teachers and/or children could be problematic. However, Lipman implies that this could be achieved through maieutic thinking, this involves '…people [teachers] who think caringly about the creative thinking of their students….[who] seek to elicit the best possible thinking from one's charges' (*ibid*:252). To achieve this, Lipman stated that the practitioner would need to understand and identify with the creative process from within. This links in with Jeffrey and Craft's (2004) comments (found at the beginning of this chapter, section 2.2-A.3) when they stated that teachers, to develop their pupils' creativity, would first have to immerse the children in their own creativity through their teaching practices. Thus, they, the teacher, would need to emphasise not only with their own creative thinking but also the students'.

Throughout I have been attempting to define the elusive abstract nature of creativity so that educators and practitioners can begin to appreciate it. Thus far I have synthesised this description: creative thinking is *the formation of all possibilities and fresh concepts that are original and useful to their creator.*

Having now given a reified form to this indescribable and shapeless concept, the notion of how creative thinking produces this outcome remains, for me, inadequate. For example, if the outcome is to be perceived as valuable and useful to the child then it would need to be driven by a yearning to want to understand it, for without this there would be no personal worth or merit in its formation. Schmitt and Lahroodi (2008:128) described this as '…a desire to know the topic without there being anything for the sake of which one desires to know it'. Dahlin cited in Milne (2011:65) claims that this is '…the aesthetic dimension of knowledge formation'. Milne goes on to say that

> 'It can be argued that there is a strong similarity between the notions of awe and wonder and the elements of fascination and anticipation that children engaged in aesthetic learning experiences can undergo. The awe and wonder factors…can become the focus or motivator for further thinking and enquiry' (*ibid*:65).

This wonder, Schmitt and Lahroodi (2008) claim, does not go onto fully describe the learners' desire to understand. That, they state, requires curiosity. Curiosity is initially driven through aesthetic reasoning, according to Richard Feynman (cited in Girod and Wong, 2002:200). Therefore, it is the child's curiosity that will ultimately drive cognitive engagement with the subject matter through wonder. This type of curiosity which drives understanding is not to be confused with '…a desire to know the topic for the sake of knowledge in general' (Schmitt and Lahroodi, 2008:128). This style of learning may only require the transfer (or accumulation) of knowledge from the teacher to the learner. Sfard (1998:5) called this the Acquisition Metaphor (AM), it lacks the shapeless and infinite topological pathways that creative thinking can offer. Curiosity itself involves self-continuation through partaking in action (i.e. actively doing), Sfard labelled this the Participation Metaphor (PM) (*ibid:*6). These are described in further depth within the methodology chapter, section 5.3.1.

Simply examining the existing literature on creative thinking is not enough to describe the range of creativity found in learning in general. It is essential to review how the current educational situation (regarding creativity) has developed over the last few decades in schools. Thus there will be a chronological review of creativity as it is set out in policy imperatives to understand how policy has motivated the development and enactment of creativity within primary schools. Before this debate the historical landscape of creative thinking will be reflected upon through eminent scientists and their scientific endeavours to try and encapsulate it's presence within the scientific domain.

2.2-A.4 Historical perspectives: the nature of developing creativity during scientific endeavours

This brief historical perspective will examine the human angle of creative endeavours, through the eyes of scientists. It is through these eminent scholars that it is possible to appreciate the characteristics of scientific thinking and working. As these features are described I will also attempt to align them appropriately with creativity as observed within the learning environment.

Isaac Newton stated that '…if I have seen further it is because I stand on the shoulders of giants'. This idea was reflected in a quote by Ibn Al-Alhaytham, an 11th century scientist who was born in Basra to an Arabian family:

> 'The seeker after truth is not one who studies the writings of the ancients and, following his natural disposition, puts his trust in them…but rather the one who suspects his faith in them and questions what he gathers from them, the one who submits to argument and demonstration and not the sayings of human beings whose nature is fraught with all kinds of imperfection and deficiency. Thus the duty of the man who investigates the writings of scientists, if learning the truth is his goal, is to make himself an enemy of all that he reads, and, applying his mind to the core and margins of its content, attack it from every side. He should also suspect himself as he performs his critical examination of it, so that he may avoid falling into either prejudice or leniency.' (Al-Alhaytham cited by Abdelhamid, 2003).

This quotation underpins Newton's 17th century citation above. The 'critical examination' that Al-Ahaytham describes starts when a problem has been found, and as previously stated, would involve the formation of all ideas/possibilities within a nebulous space. Once questions are formed then the *truth seekers* (i.e. the scientists) could systematically critique these ideas (and their own reasoned thoughts). This critical scrutiny, Al-Alhaytham theorised, would enable the current scientific theories to be studied from every perspective before a proposed explanation (or product) could be verified. This would later be referred to as the scientific method. The main strand of this thesis concentrates on creativity within the scientific domain and thus this critical scrutiny Al-Alhaytham describes is part of the way in which a scientist works.

2.2-A.4.1 Al-Alhaytham

According to the United Nations Educational, Scientific, and Cultural Organisation (UNESCO, 2015) Al-Alhaytham's own scientific breakthrough came after he was imprisoned (i.e. put under house arrest) for declining to finish building a dam on the River Nile. During this confinement he freed his mind (and saw beyond his prison walls) by critiquing and challenging the then current understandings of how light rays enter the eye. Through his experiments he made connections between his theorising and how a light source, which emanated from lanterns outside of his cell, could be reflected or refracted (utilising mirrors and lenses) to illuminate other objects in the cell, before the light entered his own eyes. He then systematically observed, examined and interpreted his own experimental results. This type of thinking is field changing and cannot be fairly compared to that of a child developing their own subjective creativity. However his critico-creative practice (imagining possibilities and crucially evaluating findings) can be experienced by both scientist and child alike.

An example of this can be related to a year 2 science lesson I observed a few years back. The class were investigating sound with two plastic cups connected by a piece of string. The children were spellbound when they realised that they could hear each other through the cups and quickly (without prompting) they developed new ways of thinking about how they could change their test parameters. Initially some simply whispered or shouted into the cup, but as they pondered and considered other variables they began to think more divergently and they reached out to their available resources (just like Al-Alhaytham and the lanterns outside his prison cell). They started to wrap the string around corners, trees and even classroom assistants. Some went on to stand on steps placing themselves higher up then their peer. Others even thought that placing the string over the varying colours painted on the playground would have an effect. As the children moved through all these ideas they scratched their heads in wonder as to why nothing (except shouting or whispering) appeared to increase or decrease their ability to hear each other. This period of engaged critical analysis and creative thinking transformed into new/different experimental actions and was only interrupted by the end of the school day.

2.2-A.4.2 George Washington Carver

History is littered with numerous possibility thinkers, all asking and imagining 'what if…' (Craft, 2001:56). These ordinary and eminent people do not let their physical or environmental confinements hinder the creative process. George Washington Carver is no exception to this rule. He was confined, not behind four prison walls, but by his own social, cultural and historical shackles. Born into slavery in the 18th century in America he had to toil hard and fight for his education. He eventually became the director of Agricultural Experimentation at Tuskegee University in 1897 (Perry, 2011). Perhaps his struggle could indicate that imagination and aspiration has no social barrier. This could mean that creativity could be found in all social classes including those families and individuals classified as poverty stricken and educationally disadvantaged (Alexander, 2010:489). This crossing of boundaries was illustrated to me when I worked with a five year old girl who would have been considered to be from a disadvantaged socioeconomic background. She displayed a gift for imagination through her use of the written language. For example the children were asked to write a few sentences about what an owl would see at night. Most of the children wrote similar sentences like: '…*the owl would see some sheep in a field'.* This five year old girl went further than this and was able to articulate her imagination through her literary creativity. She wrote about conversations which took place between the owl and other nocturnal species found in the dark, such as: '*the owl said, "hello sheep down below, you look nice and warm in your field" [referring to their fleeces], the sheep replied "Baa!, Yes we are".* Whilst where she lived and her parents' employment status may have been seen as a socioeconomic disadvantage by some (Alexander, 2010) these had certainly not hindered this girl's imagination.

2.2-A.4.3 Edward Jenner

History is not only scattered with scientists who had to overcome discrimination and prejudice. There are those whose backgrounds perhaps were more favourable. However, they still used the ideas of their scientific forefathers for the greater good. For example, Edward Jenner empathised with his surrounding community (no matter their class status). He especially wanted to help the poor, for he cared about their well-being. He achieved this by responding to a need, that is, to be rid of a disfiguring and potentially deadly disease (small pox).

Jenner employed the scientific method (as arguably intuitively carried out by Al-Alhaytham) to prove or disprove his hypothesis (The Jenner Institute, 2016). His hypothesis was that milk maids afflicted with cow pox seemed immune to the small pox disease. He set about his work applying a cow pox fluid to cuts he made on the arms of his gardener's son, James Phipps. Some days later, after James recovered from the disease Jenner applied a small pox fluid in the same way. He patiently waited for signs of the disease to manifest but James did not fall foul. Thus Jenner could conclude that he had successfully made the connection between cow pox and its ability to shield sufferers from small pox (*ibid*). In this historical story there is no evidence of Jenner gathering a broad range of scientific knowledge and/or ideas. This perhaps, led Jenner to missing selecting a better, more ethical approach to his investigation, for this form of experimentation would not be allowed in present day Western society. Jenner's life-time devotion to his vaccination (a term he coined) would eventually lead to it being valued on a sociocultural level and disseminated worldwide.

2.2-A.4.4 George de Mestral

Moving closer to the present day we discover the Swiss inventor George de Mestral (Chodos, 2003). In 1948 he took his dog for a walk and upon returning home found that both he and his faithful companion were covered with burrs from a Burdock Plant. He was curious about how these burrs had stuck so effectively. Examining the burrs through his microscope he noticed how small hooks enabled them to latch onto the tiny hoops of fabric. Hence through seeing this burr from a different, closer and finer viewpoint he conceived of the initial idea behind an innovative product he called the zipperless zipper (Suddath, 2010). His idea was so ahead of its time that there was no convenient way of explaining its formation; this is arguably an example of Sternberg's (2003) 'advance forward incrementation' model of creativity (see section 2.2-A.3.2) and thus may explain why it was met with scepticism by his peers. However he was not deterred. Through perseverance and by developing many prototypes he discovered nylon, after heat treatment, could simulate the hooks and loops. It would take him another ten years to learn how to mass produce the product. Needless to say his patience paid off. His final product is no longer called the zipperless zipper, and is better known as 'Velcro', now a multimillion pound industry and even used by NASA in spacesuits. Who is to say that the children we teach today will not produce the next revolutionary product. The girl with the nine volt battery may well find a way of recharging a battery/batteries with static electricity. After all, what was unthinkable to de Mastrel's peers (for they all thought he was wasting his time) is now in common use today.

2.2-A.4.5 Summary

Through these eminent scientists we can begin to appreciate how scientific knowledge has accumulated through thousands of years of endeavour. It would seem that scientists have built both critically and creatively upon the current and previous generations of work. This criticality was evident when Al-Alhythem challenged and questioned not only other scholars' ideas but reflected upon his own results in a similar fashion. Washington Carver epitomised creative thinking when he utilised old pots and pans to create his first laboratory due to a lack of funding. Both of these scientists have thought beyond their confined circumstances and generated novel ideas or approaches not conceived of by other humans. This type of possibility thinking was also indicative of de Mastrel when he conceptualised a product that no one had even imagined. So radical and innovative was his idea that it was dismissed by his peers. Nevertheless, his faith and patience when developing his invention was justified. Other scientists, like Jenner, responded to a medical need. Jenner took a risk (albeit with someone else's life) and discovered a vaccine for small pox. Thus through the eyes of these four scientists and their creative endeavours it is possible to discern some of their qualities. These include among others the ability to: challenge ideas, ask questions, see connections, discern patterns in data, process information, plan and carry out an investigation, be critical of other ideas and utilise resources to make something work. These traits, according to McGregor and Precious (2015:3), can be practiced and developed in primary science classrooms.

It would be interesting to try and align these actions and traits against a chronological review of creativity in policy imperatives. This will signify how creativity through scientific endeavour has been promoted, supported and potentially reified in primary schools across the UK.

2.2-A.5 Policy imperatives driving development of creativity in schools and classrooms

This chronological review of policy imperatives will provide a contextual background to the study. I have taken this approach, which is something akin to Lin's (2009) method to scrutinising research in creativity, to illustrate how policy has influenced the ways in which UK schools and teachers promote and foster creativity. This brief review of official policies will create and reveal an understanding of how the government and Ofsted have disseminated the idea of fostering creativity. The focus will, where possible, be based within primary education (key stages 1 and 2) and within the science lesson.

It was during a keynote speech at the American Psychological Association that Guilford (1950) acknowledged the potential to nurture creativity in the classroom. This was a seminal moment. Previously to this psychologists had only been interested in behaviourism (i.e. what they could physically see). Up until then the phenomenon of creativity was either seen as the need to fulfill desires or understood to be a consequence of being highly intelligent (Sawyer, 2012:15-16). Whilst Guilford's address was well received by his peers it did not have an immediate effect.

2.2-A.5.1 The Plowden report (1967)

A decade after Guilford's address the commissioned Plowden report specifically advocated creativity within the primary school (CACE, 1967a; 1967b). The report described placing the child 'at the heart of the educational process' (CACE, 1967a:7) and stressed the need for individual and personalised discovery through the environment via 'creative opportunities' (*ibid*). This report was heavily influenced by Piaget's constructivist theory (Alexander, 2010:90) which claimed that the cognitive development of children progresses in a sequence of stages. These are hierarchically arranged and experienced sequentially, as children construct an understanding of the world around them (Piaget and Inhelder, 1969). According to Brown and Desforges (1979), cited in McGregor (2007:28), the stages are:

1) sensory motor (from 0-2 years)
2) Pre-operational (from 2-7 years)
    a) Preconceptual (2-4 years)
    b) Intuitive (4-7 years)
3) Concrete operational (from 7-11.5 years) and
4) Formal operations (11.5 onwards)

When children reach the concrete stage (ages 7-11.5) Piaget's findings suggested they could assimilate simple ideas from their interactions with the world around them (McGregor, 2007). This is supported by my observation of the year two girl (aged 5) contemplating the rotation of the Earth, through a visual analogy (see section 2.2-A.3.2). Piaget envisaged children as learning from their environment and changing 'cognitively' in response to it. McGregor explains that the children actively play a role (are agentive) in their own development (and this is certainly true of the year 2 girl). However, the social interactive aspects of learning were, according to Piaget and Inhelder (1969), neglected by Piaget who reportedly envisages the child as a 'lone scientist' discovering the world for themselves. Bruner and Haste (1987) described why the notion of a child as a lone scientist should be rejected:

> '…we have fallen into the habit of thinking of the child as an 'active scientist', constructing hypotheses about the world, reflecting upon experience, interacting with the physical environment and formulating increasingly complex structures of thought. But this active, constructing child had been working alone at her problem solving. Increasingly, we see how given an

> appropriate, shared social context, the child seems more competent as an intelligent social operator than she is as a 'lone scientist' coping with a world of unknowns' (ibid:1).

Bruner and Haste suggest that through social interactions the child can 'appear' more competent and it is these social aspects of learning that are arguably neglected by the Plowden report. Nevertheless, Lady Plowden continued to insist that: '…policy and resources must be 'in harmony with the nature of the child, [and] fundamentally acceptable to him' (Alexander, 2010:91). Here Plowden was attempting to place the child at the centre of its own education but it was reported that the majority of schools during this period still taught using didactics (*ibid*). Thus the rhetoric of there being a '…golden age of freedom, creativity, discovery, child-centredness and informality in curriculum, learning and relationship' during the 60's and 70's was a myth (*ibid*:30). This was also a claim made in the 'three wise men' report:

> 'The commonly held belief that primary schools, after 1967, were swept by a tide of progressivism is untrue. HMI in 1978, for example, reported that only 5 per cent of classrooms exhibited wholeheartedly 'exploratory' characteristics and that didactic teaching was still practised in three quarters of them' (Alexander *et al,* 1992, para.19).

Practitioners therefore were still tending to follow a behaviourist teaching approach. McGregor (2007) highlights this teaching strategy as one which focuses on the acquisition of new behaviours. Behaviours that '…have been deemed to illustrate the learner has mastered a new skill…' or can recite (or mimic) correct, easily repeatable information (*ibid*:50) for the sake of attainment orientated goals (Killen, 2009). A behaviourist approach is often employed when teachers communicate or explain information in a verbal and lecture-like style, usually described and referred to as expositional teaching. This unidirectional flow of discussion is also described as didactic teaching (Kyriacou 2009) and does not incorporate the child's active or personalised development of creativity because the teacher maintains the control of the activity whilst often assuming that the children are learning what is being taught.

2.2-A.5.2 The Education Reform Act (1987)

In 1987, Gillard noted that schools, instead of focusing on the child at the heart of education, had fixated on numeracy and literacy skills (Gillard, 1987) and beyond these two disciplines there were inconsistencies in teaching between schools (Alexander, 2010:28). What these discrepancies between schools are were not explicitly disclosed by either Gillard or Alexander. The Educational Reform Act introduced the National Curriculum (NC) in 1987 (DES, 1987) to standardise education nationally (perhaps as an attempt to deal with inconsistencies). Through this act each school had to plan and teach a curriculum as set out by a legal specification (Alexander, 2010:32). This curriculum consisted of three core status subjects (Maths, English and Science) and a further seven foundation fields of study. Attainment targets were set for the three core subjects and externally prescribed tests were administered during set years. The school also had to put into place a continuous assessment system measuring on-going progress. These criteria were set out so that the progress of each and every child could be judged against national standards (Alexander, 2010:32).

Unfortunately this attainment orientated practice meant there was no reference to Plowden's child (or associated creative processes) within the NC. The only quoted source that related to the pupil, as a person, with a potential future, simply stated that the introduction of the NC was necessary because it '…equips them [the pupil] with the knowledge, skills and understanding that they need for adult life and employment' (DES, 1987:3). Thus the centralised child had apparently vanished along with the aspiration of a more constructivist approach to teaching.

2.2-A.5.3 National Advisory Committee on Creative and Cultural Education (1999)

By 1998 the then secretary of state and the secretary of state for culture, media and sport, invited Sir Ken Robinson to form the National Advisory Committee on Creative and Cultural Education (NACCCE). According to the Committee Office (2007) this report was commissioned because there was supposedly a desire to focus not just on numeracy and literacy. The NACCCE championed creativity in education. They were also the first to try and actually define it for both primary and secondary schools. Their definition was: '… [an i]maginative activity fashioned so as to produce outcomes that are both original and of value' (NACCCE, 1999:30). It could be argued that the NACCCE had reified creativity into an abstract concept only to be used during a specified creative imaginative activity, nevertheless, they were still championing an inclusive creative and cultural education based around learning and the child, not attainment levels.

Whilst the 1987 NC had prohibited the Secretary of State from prescribing favoured teaching methods (Alexander, 2010:32) the NACCCE still endorsed a teaching style that they claimed would promote and nurture their definition of creativity. The NACCCE suggested *creative* *teaching*. Bound within this term were two approaches, they were: '*teaching creatively (TC)'* which the NACCCE stated was '…teachers using imaginative approaches to make learning more interesting, exciting and effective' (NACCCE, 1999:102) and 'teaching for creativity (T4C)' which was '…forms of teaching that are intended to develop young people's own creative thinking or behaviour' (*ibid*:103). This suggested that creative thinking could either be developed by the teacher modelling it (via TC) or through the child themselves (by T4C).

Alexander (2010:44) defined this commissioned report as '…[i]mportant, visionary and timely'. Yet he also went on to describe it as '…the right report at the wrong time' (*ibid*). He claimed that it failed to restrain the government's obsession with numeracy and literacy. This is despite the expressed desire by the administration not to focus on these disciplines (The Committee Office, 2007). Robinson (2009) also reported that members of the government ended up referring to the NACCCE document as the 'arts report' (*ibid*:257). This emphasis only served to underline how creativity was not associated (by the then administration) with disciplines such as science and maths. This occurred, Alexander (2010:240) stated, because of the government's preoccupation with the 3Rs (i.e. reading, writing and arithmetic).

2.2-A.5.4 The Educational Reform Act (1999)

This focus on mathematics and literacy was reinforced within the revised NC (DfEE and QCA, 1999). The following is taken from the forward of this document.

> 'The focus of this National Curriculum, together with the wider school curriculum, is therefore to ensure that pupils develop from an early age the essential literacy and numeracy skills they need to learn; to provide them with a guaranteed, full and rounded entitlement to learning; to foster their creativity; and to give teachers discretion to find the best ways to inspire in their pupils a joy and commitment to learning that will last a lifetime' (*ibid*:3).

Whilst the word creativity was mentioned above it was unfortunately not characterised or given substance. All that is implied is that to foster it, literacy and numeracy skills must be developed first. This was a contradictory message from the NACCCE report which suggested the need for a homogenous all-inclusive education.

I acknowledge that the aims of the revised NC described how the curriculum should enable pupils to think creatively and critically.

> ‘By providing rich and varied contexts for pupils to acquire, develop and apply a broad range of knowledge, understanding and skills, the curriculum should enable pupils to think creatively and critically, to solve problems and to make a difference for the better’ (DfEE and QCA, 1999:11).

The introduction to the science programme itself also ascribes to both these ways of thinking (DfEE and QCA, 1999:76). However, it was noted that this way of thinking was not referred to within the main statutory (or non-statutory) requirements of the NC. This disembodied nature between aims and the actual curriculum appeared to be indicative of the whole curriculum. Alexander (2010:238) concurred with this opinion when he stated that the ‘aims…tend[ed] to head grandly in one direction while the curriculum slink[ed] pragmatically in another’*.*

The reason behind this separation, Alexander (2010:241) suggested, was due to two national strategies (the Literacy Strategy introduced from September 1998 and the Numeracy Strategy from September 1999). These two policies had apparently taken precedence over any other possible endorsements (including the NACCCE). Alexander stated that:

> ‘[…these national strategies were] unprecedented intervention in both the curriculum and primary education. Previous political inhibitions about directly prescribing pedagogy disappeared overnight’ (*ibid*:35).

Alexander went on to say that the perceived interference of these national strategies was reinforced from three directions. For whilst schools could theoretically opt out, because the strategies and framework had been described as non-statutory, the prescribed detailed content and the endorsement of specified teaching methods was reinforced through parliamentary rhetoric, local educational authorities and via Ofsted (*ibid*).

2.2-A.5.5 The early learning goals (2000)

In 2000 the QCA brought about the inclusion of ‘creative development’ within the Early Learning Goals. It highlighted a desire to provide children with opportunities to explore, develop and express their own original ideas through a wide variety of activities, enabling children to share ideas and stimulate different ways of thinking (QCA, 2000). This document appeared to be drawing ideas from the Plowden report. The ideology of this approach was identified within the policy framework of the newly formed national curricula as something to build upon (DfEE and QCA, 1999:23). However, this philosophy was still not evident within any of the key stages of the revised NC.

2.2-A.5.6 The Excellence and Enjoyment strategy (2003)

Next came the 'Excellence and Enjoyment strategy for primary schools' (DfE, 2003). According to Alexander (2010:36) this was published because the government had become aware of the criticisms being levelled at the national learning strategies. This report envisioned each primary school taking ownership of the curriculum to provide a broader and richer programme of study. The DfE stated that they wanted schools to aspire and develop five key characteristics of outstanding schools. These characteristics included: 'developing the distinctive character of their school', 'taking ownership of the curriculum', 'being creative and innovative' and 'using tests, targets and tables to help every child' (DfE, 2003:4). At first glance this report appeared to be offering more autonomy for the schools to be creative in their approach (Alexander, 2010:36). The document spoke of 'teachers hav[ing] more freedom than they often realise to design the timetable and decide what and how to teach' (DfE, 2003:4). However Alexander (2010) pointed out that the authors tended to emphasise numeracy and literacy as the key (or core) subjects to enable success in all the foundation subjects, for example:

> '[To enable success in all foundation subjects primary schools are expected to] use the new Primary Strategy to extend the sort of support provided by the Literacy and Numeracy Strategies to all of the foundation subjects. The Strategy will draw on our programmes for developing modern foreign languages, PE and school sport, music, the arts, and creativity. It will also help teachers use ICT to support good learning and teaching' (DfE, 2003:5).

It could be argued that this report was far from reconnecting with the philosophies of the Plowden report and its main purpose was to continue to promote the national learning strategies. It is also acknowledged by Alexander (2010:36) that documents like the *Excellence and Enjoyment strategy for primary schools*, which claimed to be about a broad and balanced curriculum, were more likely a backdrop to foreground their actual agendas such as achieving higher standards through the national strategies. Ofsted (2003) warned that the danger of doing this could lead to creative aspirations '…being seen as modish, or just one other thing to add to [the] schools' agenda (*ibid*:19).

It is noticeable that, in the above quotation, science (which was, and is classified as a core subject) was not mentioned. It could be assumed that by its absence science may not be seen worthy enough to support success in learning. Creativity also appeared to be placed in a category on its own as if it were a separate foundation subject to be taught, but only after numeracy and literacy had been mastered.

Following this review of the NC the QCA was asked to investigate how schools could promote creativity. This was achieved by examining 120 schools' existing schemes of work and lesson plans. The culmination of this project resulted in a final report called *Creativity: find it, promote it* (QCA, 2004).

2.2-A.5.7 Creativity: find it, promote it (2004)

The QCA report provided a list of strategies relating to how teachers should nurture creativity through creative opportunities. These creative opportunities were originally described in the Plowden report as enabling children to seek out their own creativity through their environment. However this was not implied by the QCA, they simply suggested that the teacher would observe five features of creativity in 'creative children' when they: 'questioned and challenged ideas', 'made connections and saw relationships', 'envisaged what might be', 'explored ideas and kept options open' and finally 'reflected critically on ideas, actions and outcomes' (QCA, 2004:10-12). However when aligned with Sawyer's model of creativity this only covered six stages out of the eight proposed (Sawyer, 2012:89). The first of Sawyer's stages neglected by the QCA was 'step 2: acquiring knowledge' - knowledge, according to Alexander (2010:247), being a component part of any discipline being studied through the NC and the second stage was 'step 8: externalising ideas' (i.e. expressing creativity through materials and representations). Hence these five visible characteristics of creativity suggest that the teachers were not looking for creativity through an inclusive NC, nor through the children externalising ideas through the creative opportunities provided by the teacher. Consequently this meant that the QCA was suggesting that the teacher should try to spot creativity when it spontaneously occurred through *creative children*. This phraseology implied that only certain children will have an innate ability to be creative and it is only they who will be able to convey their creativity externally.

Nevertheless the QCA still recommended that the teacher should promote this creative practice through their teaching. How this would be achieved (i.e. through a behaviourist approach or via NACCCE's creative teaching) was not made explicit.

2.2-A.5.8 Expecting the unexpected (2003)

In the year prior to the dissemination of the above QCA report Ofsted also took a stance on creativity with their report entitled *Expecting the unexpected: Developing creativity in primary and secondary schools* (Ofsted, 2003). It was in this report that Ofsted stipulated that the development of creativity was nothing do with a new pedagogy but could be seen within all subjects when a teacher is willing '…to observe, listen and work closely with children to help them develop their ideas in a purposeful way' (*ibid*:5). Whilst observing and listening to the children may seem reminiscent of the QCA's (2004) report, at least a teacher displaying such skills would be helping the children to develop their ideas (instead of just hoping that creativity could be captured as and when it spontaneously occurred). However as I stipulated earlier, having a purpose when developing creativity is restrictive (see section 2.2-A.3.2) for there are numerous conduits to contemplate when being creative.

The report also shifted the emphasis from developing creativity exclusively towards one of inclusivity (i.e. no-one, teacher or pupil, and no subject was excluded). The statement below from the report emphasises this point:

> '…the stimulus and structures which enable creativity to happen differ somewhat from subject to subject, this focused engagement with the individual pupil – even within a group situation – is common to all the creative work…and is of course common to all good teaching' (Ofsted, 2003:5).

Ofsted believed that creativity could vary between all subjects and none were given precedence. They also recognised how the teachers and the pupil(s) creative endeavours were both recognised as inclusive within these subject areas.

However, there are two further considerations to contemplate within this report. The first of these is Ofsted's use of the term creativity. They reportedly drew their characteristics of the creative process from the NACCCE's description of creativity. This in itself was not in question, but how this definition was applied and assessed during their many school visits, whilst formulating this report, was deliberated upon. As stated earlier, creativity could be seen as something that comes from within the child themselves through a nebulous process of imagining all possibilities, or it may be envisaged by someone as an endeavour which was judged not through the learner's own eyes but through the observer's subjective stance. Thus, from whose standpoint were Ofsted judging creativity: the inspectors or the learners? Secondly, the use of the phraseology creativity is *'common to all good teaching'* was vague

(Ofsted, 2003:5). Referring back to the Ofsted (2005) school inspection handbook does not help, for the handbook does not stipulate how creativity can be developed through the *good* descriptors of quality teaching. Thus how the creativity was actually reified and how it became common place through these practices is highly ambiguous.

2.2-A.5.9 Success in science (2008)

The *Expecting the Unexpected* report was a generalised approach to examining creativity throughout all the key stages. However in 2008 Ofsted released a report specifically examining successful science in both primary and secondary schools. This report suggested that stimulating teaching and enthusiastic learning in science took place when the pupils suggested their own ideas in consultation with their teachers.

> '…the most stimulating teaching and most enthusiastic learning occur when teachers encourage their pupils to come up with ideas and suggestions and, in consultation with their teacher, to plan, conduct, record and evaluate their own investigations. Good formative assessment is also crucial to success. When pupils receive regular feedback on how well they are progressing and clear advice on how they can improve further, they are able to focus their energies effectively. The resulting growth in self-confidence contributes to further progress. Where they take responsibility for self- and peer-assessment, their learning becomes more focused' (Ofsted, 2008:4).

Needless to say the report appeared to be endorsing a more mutual way of learning through assessment for learning and perhaps arguably endorsing T4C, as described by the NACCCE. They aligned this more mutualistic style of teaching and learning with the 'highest or most rapidly improving standards' in schools (Ofsted, 2008:5). Nevertheless creativity itself is only referred to once in this entire document:

> 'The spiritual, moral, social and cultural development of pupils has a significant part to play in science education. However, inspectors rarely see science lessons that are designed specifically to foster it. Where it does occur, it tends to result from the flair and creativity of individual teachers' (*ibid*:44)

Whilst the best development of learning is described and endorsed by Ofsted as a mutual endeavour, in actuality creativity in science is still being observed as developed through (and owned by) the teacher (i.e. through TC).

2.2-A.5.10 The Rose Review (2009)

In 2009 the final report of an independent review of the then current primary curriculum was published (Rose, 2009). This report was commissioned by the then Secretary of State for Children, Schools and Families. It included six proposed areas of learning that would make up a new curriculum and enable teachers to 'teach creatively'. These were: 'understanding English, communication and languages; mathematical understanding; scientific and technological understanding; historical, geographical and social understanding; understanding physical development, health and wellbeing and finally understanding the arts' (*ibid*:16). Through these cross-curricula areas of learning there was a suggested move away from prescribed subjects, this, according to the report, would encourage both children and teachers to think creatively i.e. 'outside subject boxes' (Rose, 2009:15). This less constricting review of the curricula was, according to Duncan (2010), welcomed by many practitioners and was putting the child back into education (i.e. it was attempting to relocate itself alongside the Plowden report).

The terms employed by Rose, in this review, included phrases such as, TC and thinking creatively, these were arguably drawn from the NACCCE report. So I refer back to the NACCCE and to its description of TC, which was, using '…imaginative ways to make learning more interesting, exciting and effective' (NACCCE, 1999:102). However, this would not, as Duncan stated, obviously place the child's creative thinking in the foreground, just the enactment of the task itself. After examining the Rose review I could also not see an attempt to clarify who initiated, or led these activities (teacher and/or child). Alexander (2010:183) suggested that this was due to the practice of trying to fit the creative ideologies around an already prescribed curriculum. This review of the NC and its recommendations were not put into practice due to a change of government in 2010.

2.2-A.5.11 Learning: creative approaches that raise standards (2010)

In 2010 Ofsted released a report entitled *Learning: creative approaches that raise standards.* Within this document Ofsted stated that good teaching was observed (in all key stages) when the NC, national standards in the core subjects (including science) and creative approaches to learning were not in conflict with one another. However, when I refer back to the Ofsted school inspection hand book there is no explanation (or evidence offered) which relates to how good teaching can associate with creative approaches to learning (Ofsted, 2005). Additionally by creative approaches I have assumed Ofsted mean creative teaching, which according to the NACCCE (1999) is defined by two terms, *TC* and *T4C*. Neither of these are referred to in this report or the Ofsted inspection handbook. Thus it is uncertain how the teacher is meant to conceptualise and then subsequently implement these practices. This ambiguity was accentuated when Ofsted (2010) stated that the definition of creativity was also widely variable between teachers. Thus, it is also speculated that the teaching approach put into practice by the teacher would be dependent on the practitioner's subjective interpretation of the term 'creativity' itself.

Creative learning in this document seemed to resonate with the QCA (2004) report when it stated that it was promoted when teachers were observed '…encouraging pupils to question and challenge, make connections and see relationships, speculate, keep options open while pursuing a line of enquiry, and reflect critically on ideas, actions and results' (Ofsted, 2010:5-6). Whilst these qualities have been associated with that of a scientist (McGregor and Precious, 2015:3) it has already been established that simply acknowledging that these five features exist in the classroom is not enough to develop scientific creativity through the NC. Teachers also need to develop strategies that actively encourage the expression and practice in the use of these traits by their children.

Ofsted also appeared to suggest that creativity would not naturally occur in all subject areas. To solve this problem they stated that '...traditionally creative subjects, such as arts and English' (Ofsted, 2010:5) would need to be incorporated into science and mathematics to promote creative learning. This suggests that Ofsted do not see science as a creative subject in itself. Smith and Smith (2010) had noted that certain disciplines and creativity do appear to '…sit and look at one another from a distance' (*ibid*:251). This, Alexander (2010:183) said, is because the curriculum tends to be devised first and the aims (which is where creativity is generally situated) are added on at a later date (something Alexander highlighted as previously occurring in the Rose review).

2.2-A.5.12 The Education Reform Act (2013)

The distance between creativity and education appeared to increase within the newly revised NC (DfE, 2013a). For whilst the word creativity resides within the aims of the new National Curricula for key stages 1 and 2, it only states that the curriculum should '….help engender an appreciation of human creativity and achievement' (*ibid*:6) and there is no mention of nurturing creativity through the pupils themselves.

In specific programmes of study there are varying levels of reference to creativity (and its synonyms). For example, in art and design both creativity and its enactments were mentioned on several occasions (DfE, 2013a), but in science the only suggestion of creativity was mentioned within the non-statutory requirements (*ibid*). Wyse and Ferrari (2015) emphasised this disparity between the arts and other disciplines when they discovered that all current UK curriculum texts referred to creativity twice as much in the arts documentation than in any other subject. However, the Science Programme of Study does mention that the children should think divergently when using varying materials and resources (DfE, 2013a:153). Whilst divergent thinking is associated with Lipman's (2003) description of imagination this is only one aspect of a more complex multifaceted process.

2.2-A.5.13 Maintaining curiosity (2013)

In 2013 Ofsted produced a report with the claim it could help support schools implement the new Science NC (primary and secondary). They entitled this report *Maintaining Curiosity: A survey into science education in schools* (Ofsted, 2013). Its title alone indicates that Ofsted have surveyed schools to find out how they maintained a strong desire on the part of the child to partake in learning science (Schmitt and Larhoodi, 2008). This yearning to learn science was observed by Ofsted (2013) when the pupils asked their own questions, made their own decisions, planned investigations and evaluated their findings. This was described by Ofsted as occurring when:

> '…pupils were involved in planning, carrying out and evaluating investigations that, in some part, they had suggested themselves. They learnt best when they could see how the science they were studying linked to real world experiences' (Ofsted, 2013:10).

This is arguably a description of learners generating and evaluating their own ideas (through critico-creative practice) via the science being studied, therefore Ofsted has recognised elements of T4C. However, how this linked directly to the NC itself I am unsure. Although Ofsted did claim that '…[t]eachers who coupled good literacy teaching with interesting and imaginative science contexts helped pupils make good progress in both subjects' (*ibid*:6). Further explanation or examples beyond this cross-curriculum approach to illustrate appropriate learning conditions (to maintain curiosity) were not reified. However the referral to an imaginative and interesting context is suggestive of the NACCCE's description of TC. Whilst Ofsted appear to have recognised both TC and T4C in this report, they do not directly link the teachers' approaches to the development of their pupils' curiosity. Thus these suggestions, as to how to observe curiosity in action, as and when (or if) it occurred, were arguably akin to the 2004 QCA report when they suggested spotting it, as it spontaneously occurred.

2.2-A.5.14 Summary

This chronological review highlighted Robinson's opinion that '…many policy makers and others…chant…mantra about the need to raise traditional academic standards…' (Robinson, 2009:78). This raising of standards can apparently be evidenced through achieving certain attainment levels in Mathematics and English during the pupil's time in school (DES, 1987) and according to Ofsted through creative approaches (Ofsted, 2008; 2010). The 2010 Ofsted report even contains this rhetoric within its title (*Learning: creative teaching approaches that raise standards*). However, the need to develop creativity within most of these documents is somewhat implicit. Perhaps within the aims, possibly only added as an afterthought once the principles being promoted had been prescribed (Alexander, 2010). This buried addition has concealed the creative qualities of a scientist, as described by McGregor and Precious (2015), that could be nurtured in science classrooms as outlined earlier in this thesis (in section 2.2-A.4).

Nevertheless, there is one report, i.e. the NACCCE (1999), which champions a more creative teaching approach as a way to nurture creativity. Since its publication the described notion of creative teaching has been referenced only a few times in other policy imperatives (e.g. the Rose review referring to 'TC' and thinking creatively'). Upon scrutinising all the other policy imperatives, it would appear that they have not attempted to synthesise any of these terms within the NC itself. This could indicate a false dichotomy emerging in education between creative approaches and the curriculum. Alexander (2010:21-22) provides a number of examples of unhelpful rhetoric that can only aid this inappropriate division, for example: 'formal versus informal', 'child-centred versus teacher-centred', 'traditional versus progressive' and 'process versus content'. Alexander however was not referring to the separation between creative approaches and the curriculum when providing these examples, he was instead referring to the imposed separation between knowledge and skill sets. He stated that the curriculum is organised in subjects and each discipline contains: 'knowledge, skills, process of enquiry, activities, experiences and much more' (*ibid*:21). He adds '…[c]oming to know is an activity, and it depends on experience, so knowledge is 'activity and experience'…and factual knowledge…is but one kind of knowledge amongst many' (*ibid*:21). Alexander's *factual knowledge* is similar to Sfard's (1998) description of the AM (which is referring to the accumulation of facts) and Alexander's use of the word *knowledge* is akin to Sfard's PM (which refers to replacing the term knowledge with the noun 'knowing' which occurs through participating).

It is my opinion that these policy imperatives need to consider not just knowledge acquisition and expressions of active participation when considering the development of creativity through creative approaches, they need to recognise how all these elements go hand in hand and can reportedly complement each other (Smith and Smith, 2010). It is with these thoughts in mind that I decided that my research should focus on the way in which the teachers practice develops, supports and ultimately reifies creativity-in-learning through the NC.

Since the focus of this research will, in the main, lay with the teacher and how their practices enable the reification of creativity-in-learning, it is their creative practice that I will examine in section B.

SECTION B

I have previously sought to scrutinise and understand the varying definitions of creative thinking through reflecting upon the nature of creativity and how this is reflected through historical eminent scientists. I have also deliberated upon how these are being (or not being) reflected through and applied via policy imperatives. Next I attempt to understand how creativity can be fostered and promoted through the teachers' practices.

2.2-B.1 Studies related to the teachers' perspective of creativity

To better understand how a teacher can promote creativity in the science classroom I first examine their understanding of how it can be fostered. There are a number of studies based around varying views of the practitioner's perception of creativity. These focus on: creativity itself (Fryer and Collins, 1991; Kamphylis *et al,* 2009); creative students (Runco and Johnston, 2002; Aljughaiman and Mower-Reynolds, 2005); creative teaching (Craft *et al*, 2007) and creative learning (Tan, 2001). Andiliou and Murphy (2010) produced a review of 17 of these types of studies and it is through this analysis that I have construed how a teacher may choose to nurture creativity.

2.2-B.1.1 Teacher creativity

In Andiliou and Murphy's (2010) review the teachers described their own creative practices, using terms such as 'encouraging openness to experience, setting few rules and assignments, providing choices, selecting prior knowledge and solving strategies, supporting development of relations and being risk-takers' (*ibid*:207-209). Unfortunately the meaning behind these six terms was not clarified by Andiliou and Murphy, thus I have attempted to explain my own formal understanding of these concepts below.

First, before I begin to examine the majority of these terms of creative practice I noted earlier, from summary of the policy imperative section (2.2-A.5.14) that the accumulation of factual knowledge (Sfard's AM) and participating in the activity (Sfard's PM) were not mutually exclusive. This, I believe, could be describing those teachers whose creative practices were reportedly 'selecting prior knowledge and solving strategies' (Andiliou and Murphy, 2010:208). However, it is acknowledged that fostering critico-creative thinking would need to go further than simply accessing prior knowledge and employing creative problem solving activities. This would also depend on how the activity was set and by whom, and subsequently how the learner's actively engaged with their prior experience, and the task itself. I attempt to describe the nurturing creativity in this way through my interpretation of three of Andiliou and Murphy's five remaining descriptors of creative practice (see the following section).

<u>2.2-B.1.1.1 The setting of appropriate tasks</u>

Three of the six terms could be grouped together. They are: 1) 'encouraging an openness to experience', 2) 'providing choices' and 3) 'setting few rules and assignments' (Andiliou and Murhphy, 2010:207-209). These three, it is postulated, can relate directly to the type of task the teacher initiates (i.e. open, semi-structured or closed).

It was Gillies and Kahn (2009) who stated that the type of task undertaken to develop creativity will have an effect on the ability to stimulate participation. They put it succinctly when they said:

> '… it is the nature of the task itself that will determine the level of interaction in the group. For example, when students participate in tasks where there is a correct or right answer to obtain…there is often little need to interact as the answer can be reached in well-structured ways. In contrast, open- and

> discovery-based tasks are regarded as ill-structured problems because there is no clear answer to the problem so students must share ideas and information if they are to resolve the problem at hand' (*ibid*:10).

It could be inferred that Gillies and Khan are stating that the task taught in a highly structured authoritative manner will limit the verbal interactions taking place and the open-ended tasks have the potential to promote exploratory conversations. It is these more exploratory tasks that I believe the teachers in Andiliou and Murphy's (2010) review are referring to when describing the three descriptors of creative practices. Chin (2003) argued that by using this open approach the children will be more likely to spontaneously and autonomously express their ideas with little prompting from the teacher. However, Wenger (2008) had provided a word of warning about allowing this autonomous participation to prevail. She stated *that* '…matters will be left unreified [and]…there may not be enough material to anchor the specificities of coordination and to uncover diverging assumptions' (*ibid*:41). Here Wenger had suggested that through these strategies not all participants will have expressed their intrapersonal conceptualisations to add to the social collective's understanding.

The above refers to children working in groups. However Driver *et al* (1994) also suggested that knowledge construction through open-ended tasks, utilising scientific conventions, should not be left up to the individual child to discover on their own.

> 'If knowledge construction is seen solely as an individual process, then this is similar to what has traditionally been identified as discovery learning. If, however, learners are to be given access to the knowledge systems of science, the process of knowledge construction must go beyond personal empirical enquiry. Learners need to be given access not only to physical experiences but also to the concepts and models of conventional science. The challenge lies in helping learners to appropriate these models for themselves, to appreciate their domains of applicability and, within such domains, to be able to use them. If teaching is to lead students toward conventional science ideas, then the teacher's intervention is essential, both to provide appropriate experiential evidence and to make the cultural tools and conventions of the science community available to students' (*ibid*:7).

A prime example of autonomous learning not reifying the science through an open-ended task can be related to a science lesson I once observed. Two year 6 boys were provided with two seemingly identical crowns (made from cardboard), but one crown was very slightly heavier than the other. They were given no instructions and a pair of old fashioned balanced scales were placed in front of them. From a scientific stance they should have been considering how the fulcrum effected the positioning of the beam when the crowns were positioned at either end. However within approximately twenty seconds they decided that the teacher wanted them to make the crowns weigh the same. They spent the next few minutes having great fun ripping holes in the cardboard, using the sharp end of their pencils. Needless to say whilst they both had a great time the scientific concept remained concealed. They left the lesson happy, but none the wiser. Therefore Driver *et al's* (1994) proposition that the invisible concepts of science have to be represented by the teacher somehow was, in this particular case, not unfounded.

McGregor (2008) has provided research that indicates how the structure of a practical science task can influence the students' learning. This study was undertaken with key stage 3 students but it is suggested that the results can be transferable to key stage 1 or 2. McGregor administered three different instructional approaches to 24 separate peer groups, in four different secondary schools. None of the groups were provided with teacher mediation during the practical activities. One set of instructions was highly structured (i.e. step-by-step instructions), the second partially structured (the problem was outlined and suggestions of issues to consider were provided) and the third was an open task (just a description of the problem to be solved was provided). According to Gillies and Khan (2009), the less defined the problem and suggested methods of inquiry the greater the potential for alternative viewpoints to be shared, debated and evaluated. This they implied would result in a wider range of methodology and solutions. The third set of instructions should therefore result in a greater number of observable collaborative processes and potential solutions/outcomes. However, in actuality, McGregor (2008) found that whilst the open-task enabled the children to proffer a wider range of variables when compared to the prescribed inquiry, none of these variables were applied during the practical activity. Also the more open task tended to be more qualitative than quantitative in nature. Interestingly, in the partially structured task the groups developed and applied a wider range of strategies, whilst trialing and openly evaluating their own ideas. They were also reportedly more likely to make predictions about what would happen within the experiment (*ibid*). This is not to say that an open-task could not work, but as Myhill and Brackley (2004) suggested, the teacher can inhibit the child's learning potential by overestimating their ability to make the right connections autonomously or by assuming that the connections are obvious to everyone. Therefore, if the teacher had monitored the learning, as Driver *et al* suggested, further exploration may have been facilitated and there could have been more opportunities for creative and critical thinking to be articulated (McGregor, 2008). I go on to describe these exploratory interactions in more detail in section 2.2-B.1.1.2 below.

The penultimate term of teacher creativity, as described by Andiliou and Murphy's (2010) review is '…supporting [the] development of relations' (*ibid*:207). This, I have interpreted as involving how the teacher engages and interacts (and builds a relationship) with the pupil. Donaldson (1987) cited in McGregor (2003:47) suggested that this can be achieved via encouraging children to use their own voices, to make sense of their own understandings. McGregor suggested this could be supported through the verbal exchanges (or social interactions) taking place between teacher and child. This is considered in further depth below.

2.2-B.1.1.2 Considering in-class verbal interactions

It was Vygotsky's (1978:86) theory that suggested learning develops in a zone between what the child is capable of doing for themselves and what they were only able to do with the help of others. Vygotsky called this the zone of proximal development (ZPD) and it is considered to be a form of mediation. Brown and Ferrera (1985) describe Vygotsky's teaching and learning interactions as follows:

> 'Vygotsky's theory of cognitive development rests heavily on the key concept of internalisation. Vygotsky argues that all higher psychological processes are originally social processes, shared between people, particularly between children and adults. The child first experiences active problem solving activities in the presence of others but gradually comes to perform these functions independently. The process of internalisation is gradual; first the adult or knowledgeable peer controls and guides the child's activity, but gradually the adult and child come to share the problem solving functions with the child taking the initiative and the adult correcting and guiding when she falters. Finally, the adult cedes control to the child and functions primarily as a supportive and sympathetic audience' (*ibid*: 281-282).

According to the quotation above the key to Vygotsky's learning theory is internalisation. However, Bredo (1999:28) stated that this would envisage children as passive receivers of knowledge. This she claimed would separate them from their surrounding social environment. Rogoff (1995:156) argued that this separation would limit any relationship forming between teacher and child and leave little room for subjective creativity to be expressed. Thus the social aspects of learning need to be considered (Bruner and Haste, 1987) to clarify how appropriately pitched and timely interactions tailored to the individual child's development can mediate the reification of critico-creative practice (i.e. expressions of creativity-in-learning).

It is through social interactions that Littleton and Mercer (2009) stated people will be able '… to think creatively and productively together' (*ibid*:1)*'.* This, they claimed, is called 'interthinking' (*ibid*). Their description of interthinking establishes that these shared exchanges involve all participants, so I would argue that in the primary science classroom this would involve both the teacher and the pupils. Having understood this I need to examine the observable talk in the classroom to appreciate how creativity-in-learning emerges. According to Mercer (2008) there are three types of talk to consider. These are:

1) Disputational, '[where t]here are few attempts to pool resources, or offer constructive criticism' (Mercer, 2008:1) and '[t]here are often a lot of interactions of the 'yes it is! – No it's not! Kind' (*ibid*).
2) Cumulative, whereby 'everyone simply accepts and agree[s] with what other people say', in doing so they '…share knowledge, but they do so in an uncritical way' because 'children repeat and elaborate each other's ideas, but they don't evaluate them carefully' (*ibid*). and
3) Exploratory, where the interactions supposedly reach for an agreement through mutual critical and constructive negotiations of ideas; here the articulated thoughts of the learner are reciprocally filtered and then spliced together (Littleton and Mercer, 2013).

These distinctions, though, do not suggest who directs or invests substantially in these kinds of interactions (teacher and/or child). To contemplate this further I propose that Mercer's three types of talk could be combined with Alexander's (2008) lesser-known five patterns of teacher talk. They are:

1) Rote, which is 'the drilling of facts, ideas and routines through constant repetition' (*ibid*:110)
2) Recitation, where '…the accumulation of knowledge and understanding [occurs] through questions designed to test or stimulate recall of what has been previously encountered, or to cue students to work out the answer from clues provided in the question' (*ibid*).
3) Instruction, which involves the teacher 'telling the student what to do, and/or imparting information, and/or explaining facts, principles or procedures'. (*ibid*)
4) Discussion involves 'the exchange of ideas with a view to sharing information and solving problems' (*ibid*) and finally

5) Dialogue, which is: '…achieving common understanding through structured, cumulative questioning and discussion that guide and prompt, reduce choices, minimise risk and error, and expedite the 'handover' of concepts and principles' (*ibid*).

The first three patterns of talk (i.e. rote, recitation and instruction) were described by Alexander as '…the bedrock of direct [or expositional] teaching' (*ibid*). McGregor (2007:61) claimed that with this direct approach to teaching the teacher maintains the control of the activity and often assumes that the children are learning what is being taught. I suggest that this portrayal appears consistent with Alexander's (2008) definitions of rote and instructional talk because during these two communicative ways the transfer of facts and instruction from the teacher to the pupil(s) is in a single direction. However, the teacher who follows the direct expositional approach, according to McGregor (2007), might expect learners to practice and be able to eventually recite correct, repeatable answers; this can accommodate Alexander's (2008) recitation, but I suggest that this third pattern of talk can (and does) go further than identifying fragments of factual knowledge, for it can also stimulate recall of what has been previously encountered (or observed). This type of communication is arguably still operating in a single direction, but this time the learner's voice is recognised. Together these first three patterns of talk are arguably somewhat akin to the description of Mercer's disputational talk, where there are few attempts (if any at all) to consider the child's perspective.

Whilst it may seem I am stating that the expositional or didactic teacher simply talks at their pupils it is important to acknowledge here that a teacher using this approach could still *perform* imaginative, interesting and exciting teaching, albeit through unilateral interaction. This kind of lesson may even enable the pupils to appreciate the wonder of the science being performed, but to satisfy their desire to understand, i.e. stimulate the learners' curiosity, Girod and Wong (2002) proposed, that this would involve participation through interaction. This collaborative environment, when exchanging ideas, was referenced by Mercer (2008) when he stated:

> 'For a teacher to teach and a learner to learn, both partners need to use talk and joint activity to create a shared framework of understanding from the resources of their common knowledge and common interests or goals. Talk is the principal tool for creating this framework, and by questioning, recapping, reformulating, elaborating and so on teachers are usually seeking to draw pupils into a shared understanding of the activities in which they are engaged.

> I find it useful to think of this shared understanding as an 'intermental development zone' (IDZ) in which educational activity takes place' (*ibid*:143).

This shared understanding (or IDZ) also resonates with Alexander's (2004) use of the term 'dialogic' teaching. McMahon (2010:31) stated that Alexander envisaged dialogic exchanges as '…a 'genuinely reciprocal' process of communication between teacher and child in which ideas are developed cumulatively over sustained sequences of interactions'. I wondered if this interactive exchange could be illustrated through the final two of Alexander's patterns of talk (i.e. discussion and dialogue).

Discussion, according to Alexander (2008:110), involves 'the exchange of ideas with a view to sharing information and solving problems'. Wells and Arauz (2006:382) stated that this communicative attempt involves participants making an effort to understand each other's perspectives in order to solve the issue at hand; this endeavour to exchange ideas was labelled, by Wells and Arauz, as the symmetry of intersubjectivity. I believe that this type of verbal exchange can be more aptly described through Solomon's (1994) writings when he stated

> 'It would be a mistake to think of intersubjectivity as if it were an agreed consensus, the final outcome of matching understanding. Nor is it having built up a conceptual structure in which "the receiver is hearing nothing which contravenes his expectations" (Glasersfeld 1989). Inter- subjectivity is a process of interchange, a dynamic during which meanings are chosen from a repertoire of language tools into which the speaker/hearers have been socialised' (*ibid*:15).

Solomon's quotation above justifies my view that Alexander's definition of discussion does not discern how these cumulatively shared ideas can reciprocally connect to form a communal *mutual* understanding (that is, the expressed thinking could be represented as an unconnected exchange of unidirectional thoughts). Wells and Arauz indirectly concurred with this when they stated that when people interact (through a back and forth interaction) 'perfect symmetrical exchanges' are rarely obtained, for, 'speakers do not always take their listeners' expectations sufficiently into account and listeners are not always able and/or willing to adopt the speaker's perspective' (Wells and Arauz, 2006:383). This description accommodates Mercer's (2008) cumulative talk because knowledge is shared through these verbal exchanges but it is done in an uncritical manner. However, if this level of communication were to be facilitated by a teacher it could still culminate into a constructed answer (although the symmetry between participants would still not be perfect at this juncture because the teacher would be guiding/facilitating the children towards a response). I could go on to argue that this construed answer illuminates Littleton and Mercer's (2009) interthinking, for the participants are working productively (and perhaps creatively if the activity is imaginative) and there is an outcome in the end. However, this will not go far enough to form Mercer's (2008) IDZ or reify Alexander's (2004) dialogic talk because a 'shared understanding' is not formulated reciprocally through the participants (*ibid*:143). McGregor (2008) believed that this type of exchange would require exploratory dialogue.

Dialogue is Alexander's fifth pattern of talk, but his description appeared to be endorsing a mediatory approach which focuses on the quick accomplishment of a learning objective. This is a behaviourist trait and lacks the explorative conversation, which Wegerif (2007) states, is required to hold '…the different perspectives together in tension…' (*ibid*:23). Wegerif believes that these varying viewpoints could then develop creativity, through the IDZ, because, as Wegerif points out, '…in real dialogue we can enter into the space between us and learn to see ourselves anew from there' (*ibid*:62). The 'anew' in this sentence being a change in perspective. This description of 'real dialogue' however, only reflects one of Sternberg's models of creativity (i.e. redefinition) and as I have previously discussed creative thinking can arguably have many more topologies (see section 2.2-A.3.2). Thus Alexander's and Wegerif's depictions of dialogue will not go far enough to explain how creativity, as I have previously described it (see section A of this literature review), can be illuminated in the science classroom.

After reasoning that dialogue (as conceptualised above) would not cater for creative thinking I turn to Littleton and Mercer's (2013) explanation of exploratory talk. This, according to Mercer (2008), requires eleven mutual ideals to occur in the classroom. They are:

> '…everyone listens actively; people ask questions; people share relevant information; ideas may be challenged; reasons are given for challenges; contributions build on what has gone before; everyone is encouraged to contribute; ideas and opinions treated with respect; there is an atmosphere of trust; there is a sense of shared purpose and finally the group seeks agreement for joint decisions' (*ibid*:1)

Littleton and Mercer report that these exploratory interactions supposedly reach for an agreement through mutual critical and constructive negotiations of ideas, where the articulated thoughts of the teacher and the learner(s) are reciprocally filtered and then spliced together. Wells and Arauz (2006) would state that this reciprocity is essential for a ‘perfect symmetry of intersubjectivity’ (*ibid*:383). They go on to highlight why this is important:

> ‘Not only do children not always understand what they are told…[they] need to engage in clarifying dialogue to reach the desired intersubjectivity, but frequently they also have alternative perspectives on a topic that need to be brought into the arena of communication and explored in more symmetric dialogue in which there is reciprocity in the roles of speaker and listener’ (*ibid*:387).

It was Robinson (2009:153) who stated that this can be achieved through all participants ‘…elaborating on the initial idea, testing and refining them and even rejecting them, in favour of others that emerge during this process’. This description is more in-line with McMahon’s (2010:32) description of Alexander’s (2004) dialogic talk, whereby ‘…children, as well as teachers, initiate interactions by asking questions and making suggestions, and that children listen to each other and are actively involved when they are not speaking’. For participants to serve as critical and creative resources for each other in such a manner (i.e. to challenge each other appropriately) Rogoff (1995) suggested that a period of apprenticeship would be required. During this apprenticeship the children would develop the ability to listen to each other, invite opinion and listen to alternative views (Alexander, 2010). However, I recognised that the eleven ideals of Mercer (2008) do not mention this unspecified time period.

Whilst Littleton and Mercer (2013:3) have claimed that ‘the study of the process of interthinking and the role of language in it, has been strangely neglected’, I reason that it, as a concept, does not go far enough to examine the critico-creative thinking required to illuminate creativity-in-learning and that it needs to be reconceptualised and pushed further to reify creative thinking. To this end I offer an illustrated model of the varying forms of talk available in the classroom (See table 2.1 below). This framework examines both the teacher-child exchanges and child-child interactions.

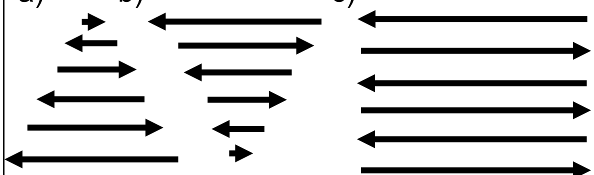
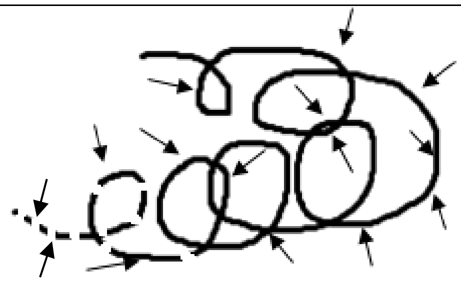
Five Patterns of Talk * adapted from Alexander (2008)	**Direction and extent of verbal exchanges**		**Three types of Talk** * adapted from Mercer (2008)
	Teacher to Pupil(s)	**Pupil to Pupil**	
Rote			Disputational
Instruction			Disputational
Recite			Disputational
Discussion	a) b) c)  *Measure of participants engaging with each other in discussion (symmetry of inputs/contributions from pupils in classroom – ideas are not critically connected) Figures a-b – symmetry in verbal exchanges not necessarily equal from all participants. Figure c – equal symmetry in verbal exchanges*		Cumulative
Dialogue	 *Extended/ perfect reciprocity in verbal exchanges (critico-creative engagement) between teacher and pupils.*		Exploratory

Table 2. 1: A proposed model of the types of verbal interactions observed in the classroom

Table 2.1 illustrates both rote and instruction as passively transferring information on a single path from teacher to pupil (reference the single unidirectional arrows), whereas recitation acknowledges the limited interaction of recalling information when an examiner asks questions (note the addition of a small anti-parallel arrow). When these types of talk are exchanged between pupils the information can still be conveyed passively in one direction (see the first two disputational rows). If exchanges do occur (i.e. the children recite information to each other) the verbal interactions still remains linear and restricted (notice how the arrows are small in length and do not overlap each other). As Mercer (2008) stated in this exchange there are relatively few attempts to group articulated thoughts together and they will not interweave with one another.

Alexander's (2008) discussion and Mercer's (2008) cumulative talk are represented on table 2.1 as a layering of information, an exchange of unidirectional symmetric ideas, (reference the antiparallel arrows in figures a, b and c). If this conversation were facilitated by a teacher it could be layered into a form of constructed knowledge. This is represented by three sets of incrementally decreasing (table 2.1, figure a) or increasing (table 2.1, figure b) anti-parallel arrows. I suggest that the arrows are representative of the attempts of the participants to understand each other's perspectives through intersubjectivity, but without the reciprocity of perfect symmetrical exchanges taking place (Wells and Arauz, 2006). However, if this discussion is not mediated appropriately then there is a risk of any knowledge and/or learning taking place remaining unidentified and/or unarticulated (Wenger, 2008). This is illustrated in table 2.1 as figure c (i.e. the equivalent lengths of anti-parallel arrows representing the exchange of ideas and nothing more).

The fifth and final type of verbal interaction I have labelled as exploratory dialogue, it is illustrated on table 2.1 as a shared cognitive spiral which twists and bends back in on itself as ideas are critically and creatively conveyed. These thoughts if mutually accepted by the collective are at the same time spliced into its formation. This, I have construed as being the 'perfect symmetry of intersubjectivity' (Wells and Arauz, 2006). The initial ideas articulated by the participants are represented as dashed lines and smaller arrows are the thoughts and ideas that sequentially or simultaneously occur throughout this mutual exchange for further consideration. Whilst only one pathway is illustrated on table 2.1 (in a singular static form) this depiction serves to provide an example of one potential critico-creative pathway. For I recognise Sawyer's (2012) description of creative thinking where the pathways are unknowable and the routes available are not only infinite but also unpredictable.

When considering the types of verbal exchanges taking place in the classroom I want to keep in mind Bird's (2011:94) stance when he challenged the view that 'only exploratory talk was of educational value':

> 'I would contest the view that only 'exploratory' talk is of educational value. Firstly, 'disputational' talk arises in the moment of exchange and while the positions of those involved may well be fixed during it, this does not mean that these positions become fixed forever…Similarly, cumulative talk may imply a

> lack of questioning by individuals, but this does not mean that outside the immediacy of the exchange itself, questioning does not subsequently take place…it is important to consider types of talk or interaction which signify participation and evolving competence' (*ibid*).

Here Bird is suggesting that it was important to consider all of Mercer's (2008) three types of talk when examining classroom interactions (and thus all of Alexander's five patterns of communication), for he advises that all forms of verbal exchanges can indicate participation. This, Bird is stating, could occur within the immediate conversation taking place on an intrapersonal level, or outside of it during a future unspecified period of time. With this in mind I offer the above theoretical framework (table 2.1) as a means to interpret any and all verbal classroom communications which occur during science lessons.

Having created a fresh theoretical framework of classroom verbal interactions, which can be employed to illuminate creativity-in-learning, I am also drawn to Mercer and Hodgkinson (2008) who have highlighted how I need to consider the types of actions taking place, the practices initiated by the teacher, and the texts produced during a science lesson. They noted that this provides '…a way of making visible how the communicative system…was tied to [these] particular events' (*ibid*:14). This they illustrated through a textualised table, otherwise known as 'a map of events' (*ibid*), which made explicit all of the activities/strategies employed to mediate the social actions and reactions (physical and verbal) of both the teacher and learner from the beginning to the end of a lesson. It is with this in mind that I propose the setting of appropriate tasks (section 2.2-B.1.1.1) and the in-class verbal interactions are inseparable when considering both learning and creative opportunities in science. This requires further consideration and will be reflected upon in greater depth in the methodology chapter (section 5.6.2.7).

It is intended that by examining the patterns of talk and by producing an illustrated map to timeline specific events I could reflect upon the ways in which the teacher and children verbally (and actionally) interact with one another to demonstrate (and possibly unlock) the creativity of young learners during a science lesson.

I recognise that in the science classroom these two analytical frameworks will not go far enough to examine the emergence of all creative realities (Sawyer, 2012) due to the subjective and personal nature of the interactive experience. However, the freedom to express creative thinking could be related to the final characteristic of teacher creativity, which, according to Andiliou and Murphy (2010) is the ability of the teacher to be a *'risk-*

taker', or allow for *'risk taking'*. Unfortunately risk-taking is not fully described by Andiliou and Murphy so I have had to study how other scholars have typified this trait.

<u>2.2-B.1.1.3 Risk-taking</u>

Warwick and Dawes (2013) have described risk-taking as the willingness of the individual child to express '…their understanding [and] share their thoughts about how they might work to develop their knowledge' (*ibid*:56). This definition however, depends on what Warwick and Dawes mean by the term knowledge and more importantly how the practitioner interacts with this word. For example, does this refer to the acquisition of factual knowledge (through Sfard's AM), or does it relate to the child's participation in the activity plus their prior experiences (Sfard's PM). Thus I am unsure of how this definition can (or should) be employed through the teachers practices.

Risk-taking was also linked with autonomous learning by Cremin *et al* (2013:16), she advised that when children learn independently the teacher should model a tolerance of ambiguity, by being open-minded, curious, enthusiastic, and playful. However, as discussed earlier, if autonomous learning were taken to the extreme then there is a danger that not all participants will have accessed the relevant scientific conventions (Driver *et al,* 1994), and they could draw incorrect conclusions or ideas from the activity, as was the case with the two boys and the two crowns (see section 2.2-B.1.1.1). To counter the potential of any learning not being aligned with scientific conventions a teacher who risk-takes, Cremin *et al* (2013:16) claimed, should be flexible, and respond *appropriately* to these alternative ideas and suggestions. Haug (2014:79) called these unexpected occurrences 'spontaneous teachable moments' where the teacher is required to adapt the course of the lesson to suit the students' needs. McCallum *et al* (2000) suggested that children preferred this more open approach to teachers who overly controlled the activity because it enabled them to follow up on their own ideas. This, Oliver (2006:30) proposed, increased the opportunities for children to see things afresh and make tangible connections.

In summary then, for the purposes of this thesis I shall envisage a teacher who is a risk-taker to be someone who is open-minded, curious and playful, and encourages the children to see things afresh by challenging ideas.

By scrutinising the five features of teacher creativity above (see first paragraph of section 2.2-B.1.1), as specified by teachers through the Andiliou and Murphy review (2010:207-209), we are left with three tangible characteristics of a practitioner fostering creativity. They are:

the appropriateness of the task, examining verbal interactions and risk-taking. I however, would like to add a fourth, which is fostering autonomy; this agentive independence has resonated throughout the three characteristics described above and is examined in more depth below.

2.2-B.1.1.4 Fostering autonomy

According to Craft (2005) the nurturing of creativity in children requires them to be independent (autonomous) learners. To achieve this the NACCCE (1999), Rose (2009) and Cremin *et al* (2013) suggested that the teacher offers independent control of the activity to the children. I add to this McGregor's (2007) recommendation that expectations are set. These expectations however, are not to be confused with the performance outcomes (or setting a purpose which is counter to the limitless nature of creative thinking). McGregor stated that setting expectation occurs when teachers:

> '…convey clearly when and where they 'expect'… different kinds of cognitive or learning behaviours so that pupils realise that 'conforming' with others' views, or the teacher's perception of the 'correct' answer is no longer the assumed expectation…' (*ibid*:253).

Thus when encouraging creativity McGregor stipulates that all possible answers could be considered acceptable. Davies (2011:15) believed that this type of open ethos will enable the learners to feel confident and safe enough to speculate. For the purposes of this thesis I will define encouraging autonomy as offering independent control of the activity to the children and welcoming all possible ideas. Although I recognise that generating all possibilities was previously recognised as an individual facet of imagination (section 2.2-A.3.3) and being imaginative was only one aspect of creative thinking (section 2.2-A.2 - A.3).

In summary, the teachers in Andiliou and Murphy's (2010) review perceived creative practice as involving the type of task undertaken, verbal interactions and predispositions towards risk-taking. In addition to these I additionally acknowledged encouraging autonomy. It is these four aspects of creative practice which I intend to keep in mind whilst I observe teaching practices which reportedly augment the development of creativity.

I have described these creative practices to better understand how teachers may develop creativity in the classroom, but Andiliou and Murphy briefly referred to the idea of policy (and culture) effecting the teachers' acceptance of creativity in the classroom:

> '…[teachers] beliefs about creativity may be associated with aspects of the educational system and curriculum such as the underlying values and objectives related to creativity and the values and supports provided to teachers to enhance… creative thinking…' (ibid:217).

This quotation is implying that policy and culture may be having an effect on how creativity is being promoted in the classroom. I certainly found that numerous policy imperatives, in section 2.2-A.5, appeared to mainly focus on achieving higher attainment levels (or standards) whilst skills, such as creative thinking, appeared sidelined (Alexander, 2010). Nevertheless, how these high standards were to be achieved through the NC statutory requirements had been left up to the individual teacher to interpret.

According to the NACCCE (1999) and Oliver (2006:22) a creative practice could incorporate both the NC statutory requirements whilst nurturing creativity. This creative approach to teaching was previously described in section 2.2-A.5.3 and is reportedly composed of two teaching approaches. They are: TC, which focuses on the teacher's use of imaginative approaches and T4C which centers on the development of the children's own creativity (Davies, 2011:14). Davies recommended that neither should be considered mutually exclusive. By separating these two teaching methods Alexander (2004) was concerned that it may create an ideology that assumed one approach should predominate over the other. To fully appreciate how creative teaching (and both its composite teaching approaches) can mutually nurture creativity, further scrutiny is required.

2.2-B.2 Creative teaching: an introduction

It was suggested that examining creative teaching (i.e. TC and T4C) can provide some understanding of the conditions required to deliver opportunities to stimulate creativity in science. The literature available which describes these two practices can fail to adequately suggest how these teaching approaches sit together (Oliver, 2006). Some literature even implies the mechanised application of practices deemed to characterise creative teaching would suffice (Best and Thomas, 2007) without due consideration to how creativity-in-learning could be reified. Thus there is limited source material about the provision of developing creativity through these approaches.

To augment creative practice Oliver (2006) identified ten ways to make science teaching creative. These are:

1) ‘Turning predictable outcomes into something better
2) Making the ordinary fascinating
3) Sharing a sense of wonder
4) Seeing differently
5) Maximising opportune moments
6) Humanising science
7) Valuing questions
8) Modelling explanations
9) Encouraging autonomy and
10) Allowing for flexible beginnings’ (*ibid*:150-158)

In recent years these have been reconsidered and reconceptualised by Davies (2011:18-22) and Davies and McGregor (2017:18-24). These ten ways, as described by Oliver, Davies and McGregor, will be considered and reflected on in the following sections with the aim being to appreciate and understand what a teacher can do (or does do) to support the development of creativity in the science classroom. To consider TC and T4C I will also, when appropriate (or if possible), consider these descriptions of the ten categories through the lenses of Davies’ (2011) description of creative teaching, where he states that,

> ‘[Creative teaching is] composed of two distinct elements ‘teaching creatively’, where the focus is on *me the teacher* (or perhaps more helpfully *us as a team of teachers*) and our ability to communicate science in as creative way as possible, and ‘teaching for creativity’ where the focus is on the *creativity of the learners* and our role is to teach in such a way as to enable the children to express and develop their creativity’ (*ibid*:14).

With Davies’ explanation of creative teaching in mind I will therefore be contemplating whether aspects of creative teaching, as described through these ten categories, can be associated with either teacher-initiated/led creativity (i.e. TC), or whether there are opportunities provided, by the teacher, which could be focused on the children’s expressions of creativity (T4C).

After examining and reflecting upon Oliver’s ten categories I will attempt to define each (see *italicised* sentences at the end of each sub-section). This is not intended to create a static reification of a more complex issue, but an attempt to conceptualise an analytical framework (which incorporates both the teacher initiated creativity and the child being enabled to be agentive in their creative efforts) to examine survey responses. This framework is described in further detail in the methodology chapter, section 5.6.1.6.2.2.

2.2-B.2.1 Oliver's ten ways to make science teaching creative

Below I describe and interpret the ten ways to make science teaching creative in the same order in which they were originally listed by Ann Oliver.

<u>2.2-B.2.1.1 Turning predictable outcomes into something better</u>

Oliver (2006:25) states that this first way for a teacher to make science creative includes '[m]aking the commonplace intriguing', she reports why this is important, '[s]cience lessons which follow a predictable route on a regular basis will do little to raise curiosity or inspire wonder. The time to worry about quality in science teaching is when predictable knowledge and outcomes surface' (*ibid*). This describes a concern that planned activities, which pursue specific answers and/or have predefined products, may not capture the children's interest. To try and underpin a creative approach which circumnavigates the expected I turn to Davies and McGregor (2017:20) who suggested that this category should be referred to as, 'reviewing established approaches with creativity in mind'. By established approaches I am assuming that they are referring to what they call a 'passive activity' (*ibid*), that is, a pre-planned lesson whereby the transfer of knowledge from the teacher to the learner lacks the potential to produce alternative possibilities (Sawyer, 2012:396). To review these conventional approaches (with the child's creativity in mind) I refer back to an earlier suggestion where I had proposed that creativity required the stimulation of the pupil's curiosity (this is originally described in section 2.2-A.3.4, as a personal desire, on the part of the child, to actively partake in the activity, and learn). This inquisitive nature, I suggested, began by igniting the children's wonder, which develops through a teacher using a creative, imaginative approach. If this is also connected to the commonplace (or the children's everyday experiences) it could provide a link to Craft's (2001) 'little-c' creativity where the children actively explore the notion of 'possibility thinking', whilst tackling everyday challenges.

Tackling commonplace experiences through agentive possibility thinking has also been depicted as a characteristic of eminent scientists, such as George de Mastral and George Washington-Carver (see section 2.2-A.4). Thus this approach, it is anticipated, could also enable the children to naturalistically employ (and express) their own scientific inquiry skills. To engage the learners' with these scientific instincts, through everyday challenges, Oliver, Davies and McGregor offer several strategies. For example, 'finding the best curtains to help baby bear go to sleep…[this included providing the children with] a variety of curtain fabrics chosen for similar properties' (Oliver, 2006:25) or making a pinhole camera to 'challenge children's ideas about how we see' (Davies, 2011:18; Davies and McGregor, 2017:20). The implementation and resourcing of the activities implied that it was the creative practitioner's responsibility to combine these suggestions in the most appropriate and purposeful way to promote and enhance learning in science, but the descriptions of these activities did not mention the challenges the children will face, to engage with their little-c creativity. However, Oliver provided a further list of no less than 13 teacher-initiated approaches which reportedly immerse the pupils in their own scientific learning. These are:

- 'using questions to which there are several answers;
- providing demonstrations specifically to raise curiosity;
- using analogies and models to promote understanding;
- varying methods of recording;
- studying the approach of different scientists;
- ensuring research has purpose and application;
- addressing complex scientific ideas in a practical and relevant way;
- using resources imaginatively;
- comparing different viewpoints;
- making cross-curricular connections, such as drama, art and music;
- valuing play and exploration;
- giving children thinking time;
- focusing on the quality of ideas, comments and observations' (Oliver, 2006:25)

This list still appears to weigh the creative teaching dichotomy towards the teacher resourcing and initiating the activities. If creativity is to be construed through the children it is not just about 'reviewing established approaches' but also about considering who initiates and subsequently leads them (teacher and/or child). Therefore, whilst I agree with Oliver that *turning predictable outcomes into something better* occurs when *making the common place intriguing, by not following a prescribed route.* I would also add that it is the manner in which the teacher interacts with and mediates the 13 listed suggestions, plus the level of autonomy offered to the children that will denote whether the construction of scientific concepts is done creatively (through the teacher) and/or for creativity (via the active participation and articulated expressions of the pupil).

2.2-B.2.1.2 Making the ordinary fascinating

Oliver (2006) described *making the ordinary fascinating* as using '[e]veryday objects and phenomena…creatively to stimulate interest' (*ibid*:26). If I give consideration to my interpretation of the first aspect of creative practice (in section 2.2-B.2.1.1 above) this stimulation of interest, from the child, could be from a creative activity designed to provoke wonder and spark the child's active participation (their curiosity) through their everyday experiences. This practice, Oliver was quoted as saying, would allow the pupils the '…[f]reedom from prescribed [passive] teaching methods', this reportedly being 'a precursor of creativity' (*ibid*:27). Whilst this describes a teaching practice free from prearranged strategies I noted the use of the word 'creatively' within her initial description, which is reminiscent of the NACCCE's (1999) description of TC, and this is therefore suggestive of a teacher-orientated activity. This focus on the teacher was tempered by Oliver when she proposed that linking to the ordinary could help young learners take the lead and make their own abstract connections between science and their lives. To achieve this she suggests that the children are considered when planning the science lesson. Oliver went on to describe an investigation she had planned and initiated, as a teacher, whereby children (in groups) were provided with specific resources (bread, candles, sand trays and test tube holders); and then she reported that the children employed these materials themselves, to investigate and consider the physical and chemical changes of burning toast. Thus the activity outlined by Oliver was teacher-initiated (TC) but there was a possibility of it becoming child-led. Davies and McGregor (2017) went on to say that to encourage the children's expressions of interest further (to illuminate T4C) the teacher needs to '…help them [the children] see things they take for granted [like burnt toast] with fresh eyes' *(ibid:21),* they claim this will enable the pupils to see everyday phenomenon in a new light. Whilst this description resonates with Sternberg's second model of creativity, i.e. redefinition, (see section 2.2-A.3.2) there is only one trajectory of creativity being illustrated here and creative thinking arguably has many more topologies than this. Thus its development is more multifaceted than this singular depiction (Robinson, 2011) and this requires further consideration. Whilst I have argued that the examination of Oliver's original definition of *making the ordinary fascinating* does not reveal all the possible conduits of creativity, I feel I can still discern both TC and T4C standpoints through Oliver's original definition offered at the beginning of this section. However, the removal of the word 'creatively' is necessary, for this infers a teacher-led approach and will not allow me to pay due consideration to the possible expressions of child creativity. Thus to incorporate both the teacher's and children's creative attempts in the science classroom the definition of *making the ordinary fascinating* becomes *considering everyday objects and phenomena to stimulate interest.*

2.2-B.2.1.3 Sharing a sense of wonder

Wonder was described, in section 2.2-A.3.4, as a prerequisite to curiosity (i.e. the pupil's yearning to learn). This was reportedly driven through fascination and anticipation (Milne, 2011:66). Oliver (2006:28-29) advised that in the science classroom these emotionally charged experiences could be disseminated by finding the extraordinary from within the ordinary. To convey this wonder Oliver suggested strategies such as pondering upon historical misconceptions, for example, thinking about why people, in the 1950s, believed they were being watched through a television screen, or she suggested examining natural phenomenon, such as a starfish regenerating lost limbs (*ibid*:28-29). All of these, whilst creative, would require the teacher to draw the children's attention to them (i.e. they are teacher-initiated), additionally they also may not be common place occurrences from the primary school aged children's perspectives. However, Davies (2011) went on to consider this through child-led exploration where the children choose to examine and explore that which occurs within their natural environment, such as, 'the way that sunlight casts shadows and bright or colourful patches on the classroom wall' (*ibid*:19). Davies advised that during these periods of child-led discovery teachers could stimulate their pupils' interest by expressing amazement through 'I wonder' questions and exclamations of 'Wow!' (*ibid*).

I feel this is an apt time to acknowledge Davies and McGregor (2017:21) when they refer to Oliver's third category as 'developing a sense of wonder' (not sharing). This may be a better description, for the word 'development' implies there is a potential progression between wonder and curiosity, or that there is a possible transition between a teacher initiating these extraordinary scientific investigations (TC) and the children being provided with the opportunity to express their own sense of astonishment (T4C). However, because I plan to directly refer to Oliver's ten categories when analysing survey data (see chapter 6) I shall only incorporate the word development into my definition of sharing a sense of wonder and not alter the title of the category itself. Having now given consideration to the above I shall envisage Oliver's category of *sharing a sense of wonder* as involving all people in the classroom (teacher and/or child) when *developing and disseminating a sense of amazement at the surrounding environment and world.*

2.2-B.2.1.4 Seeing differently

It is interesting to note that Davies and McGregor (2017:21) referred to this category not as *seeing differently* but as *'looking differently'*. They used the example of Antonie van

Leeuwenhoek’s microscopic observations to explain their reasoning. This is akin to George de Mastrel looking down his microscope for the first time (see section 2.2-A.2.4). However, by changing the verb from *seeing* to *looking* it implied, to me, that the observers were simply staring at something (i.e. through another means: the microscope). Thus de Mastrel would have only looked at the tiny hooks from the burrs of the Burdock plant without perceiving, considering and discerning what they were. I am not implying that Davies and McGregor are incorrect because by looking from another vantage point it may help a learner to appreciate something afresh, this is akin to Sternberg’s (2003) second model of creativity, redefinition (see section 2.2-A.3.). However, it is the term *seeing* that is suggestive of so much more (e.g. perceiving wonder and potentially stimulating curiosity).

Within Oliver’s (2006) explanation of this fourth category she mostly referred to changing children’s perceptions through historical scientists perspectives, perhaps because ‘…seeing differently is not only acceptable but an admirable quality for a scientist to have’ (*ibid*:30). This implies that this change in viewpoint can develop from an understanding of the natural abilities and strengths of a scientist. Thus Oliver was implying that it was necessary to understand the nature of human endeavour when pursuing scientific goals, something I have alluded to previously (see section 2.2-A.2.4). It is important to note here that there are far more qualities that belong to a scientist than just perceiving something from an alternative perspective, for example McGregor and Precious (2015:3) describe a scientist as someone who also challenges ideas, asks questions, seeks connections, the list goes on (this list was originally referred to in section 2.2-A.5.11).

Whilst Davies (2011) concurred with examining seeing differently through a historical view he also appeared to believe that the child’s ability to see differently required teacher-direction.

> ‘In order to make the ordinary fascinating to children or help them to express wonder at the everyday scientific phenomena around them, the creative teacher has first to help them see the world differently – through a scientist’s eyes perhaps, but maybe also as an artist might see it…’ (*ibid*:19).

Davies is describing a teacher-initiated approach, which he appears to associate with two of the categories previously described, they are: *making the ordinary fascinating* and *sharing a sense of wonder.* However, he is claiming that before these can be employed by the teacher the learner needs to be taught how to *see* from another viewpoint (perhaps from a scientists’ perspective and/or as an artist). If this is achieved and a child perceives the world through another person's perspective (and does more than just look at them historically) this could enable the child to distinguish the difference between internalising the scientist's accomplishments (by acquiring knowledge from the teacher) and actively partaking in and knowing the qualities of them as a person. Interestingly, Davies does not describe this difference between acquiring knowledge and active participation in his description of this category, which is akin also to Sfard's (1998) AM and PM, he simply states that this other perspective would enable the learners to express their wonder at the everyday.

Having considered the above, and recognised that *seeing differently* is about more than just looking, for it is about discerning something afresh through investigation (akin to working scientifically, not unlike past eminent scientists) I can now classify this fourth feature as the teacher and/or child recognising opportunities to *change perspectives so that fresh varying perceptions can be discerned and/or considered.* By defining it in this manner aspects of creativity (e.g. Sternberg's redefinition) could potentially be expressed, but I acknowledge that the articulation of creativity-in-learning (such as critico-creative practices), will still depend on the nature of the exchanges taking place within the classroom itself (these verbal interactions have been described in section 2.2-B.1.1.2).

2.2-B.2.1.5 Maximising opportune moments

Oliver (2006:31) explains how to maximise opportune moments by stating, '[m]inute by minute scientific connections can be made with everyday events. Teachers can use fleeting moments to focus thinking; [for] making connections between unrelated ideas is crucial to creativity'. From this quotation I note two things, first Oliver is describing this category as being teacher-led, and secondly it is a perfect example of Sternberg's (2003) model of integration, where an individual combines two ideas, or ways of thinking, together. However, this is just one model of eight others offered by Sternberg (see section 2.2-A.3.2) and Sawyer (2012:91) goes on to propose that there are many other (infinite) ways to be creative, thus making connections is not necessarily a prerequisite to creativity. Davies (2011) tempered Oliver's phraseology by stating that maximising opportune moments could 'spark children's creativity' (*ibid*:20), that is, he is indirectly stating that the making of these connections may not be 'crucial to creativity' but it can potentially stimulate/ignite it.

To demonstrate this notion of a teacher (not a child) sparking creativity Davies (2011) used the example of an unexpected problem occurring during an electronics lesson, he referred to 'a circuit containing a lamp and buzzer wired in series' (*ibid*:20), the buzzer could sound but the lamp may not work. He claimed that this could provide the opportunity to 'spark new ideas for enquiry' (*ibid*), but this, he stated, requires a teacher '…holding on to the notion of possibility in what may seem to be adverse situations' (Craft 2000:3, cited in Davies 2011:20) and actively asking their pupils to consider alternative ideas and/or solutions. I have previously illustrated how this type of teacher-initiated activity could potentially illuminate Sternberg's reconstruction model of creativity (see section 2.2-A.3.2).

Proposing that the teacher draws the learner's attention towards the scientific, during these opportune moments also suggests that this would depend on the teacher spotting (and initiating) these sorts of opportunities if (or when) they occurred. To provide an example of such an opportune moment Oliver (2006:30) described a rural walk with a group of year 6 pupils. Upon seeing frogspawn, and some woodlice the children reportedly spontaneously made enquiries. An apt illustration of my own occurred during an outdoor activity, a group of year 1 children paddling in a small creek wondered why there were crab apples floating downstream. The early year pupils were heard to say, *'River's don't grow apples', 'Why are there so many apples in the stream?'* and *'Why are they so small?'.* This was a child-initiated (spontaneous) line of enquiry, but it was arguably not an expression of little-c creativity, whereby the children try to solve the issue at hand, because the children did not critically engage in seeking answers to these questions. Davies (2011:20) suggested that the development of appropriate scientific questions at this juncture could have ensured further exploration. The concept (of valuing and developing these types of investigative questions) will be examined further in section 2.2-B.2.1.7 below.

The idea of observing the children being creative, as they investigate their natural environment, links this fifth feature of creative practice with the four previous categories (see sections 2.2-B.2.1.1 – B.2.1.4). However, noticing it in children (if creative thinking happens), and then developing it, suggests the QCA (2004) report, *creativity: find it. promote it*, was an apt summary of developing creativity in the classroom (this report was previously examined and described in section 2.2-A.5.7).

Having given consideration to teacher-led activities/enquiries (TC) and the learners' expressions of Sternberg's reconstructive model of creativity (an expression of T4C) I now envisage *maximising opportune moments* as involving everyday phenomena which can be employed by both teacher and child to *create (spontaneous) links to the scientific.*

2.2-B.2.1.6 Humanising science

When humanising science Oliver (2006) suggested that the teacher could encourage the children to study the lives and characteristics of scientists'.

> 'If teachers suggest children study the lives of scientists they are usually concerned with humanising science as well as exploring the purpose and nature of science. I see this as no bad thing to do. Children can be encouraged to consider certain characteristics, noting attitude, risk-taking and the nebulous nature of creative thought. Science discovery is not an easy journey; it is never certain and creative thinking is needed to make connections, see possibilities and accept failure. By looking at the lives of scientists pupils will be helped to recognise science as a human endeavour…' (*ibid*:32).

Through studying these scientists, Oliver was suggesting that children could begin to understand that science was exploratory, and not a straight forward prescribed journey (a similar description to my definition of Oliver's first way to be creative). I would also add, it can provide the opportunity for the children to learn that creativity-in-learning is not just about expressing all possible creative ideas and/or thoughts (e.g. the spontaneous ideas/questions raised by the year 1 pupils playing in the stream, which were not considered further), but also about critical thinking, that is, the scrutiny of known information and data. This is something I have referred to earlier (see sections 2.2-A.3.3). Whilst contemplating this I have also considered Davies's (2011) explanation of how to reify this category, that is to 'look for the human angle in any science topic' (*ibid*:20). I suggest Davies's description should go further, that is, the children should 'see' (not look for) the human side of science, whilst tackling challenges (the reason behind this change in verb are outlined in section 2.2-B.2.1.4). By doing this the children would be naturalistically employing their own scientific inquiry skills/instincts, whilst additionally being able to perceive, consider, discern and imagine something new through another person's perspective. I, therefore, suggest that the pupils are humanising science (i.e. making science more human) when they *see the scientific through human endeavour, that is by considering/participating in the characteristics of (past or present) scientists.*

2.2-B.2.1.7 Valuing questions

When Oliver describes valuing questions she envisages children identifying and raising their own questions spontaneously, in a similar fashion to the year 1 group of pupil's paddling in the stream and vocalising their interest in the crab apples floating past them (see section 2.2-B.2.1.5). She goes on to say that: 'If children believe that questions have value and that an answer is not necessarily the end of the debate, they will be more willing to ask more sophisticated and productive questions' (Oliver 2006:32). Ofsted (2013:40) even stated that this ability to raise questions was a sign of children expressing a strong desire to learn. This, on the surface, appears akin to Schmitt and Larhoodi's (2008) description of curiosity. However, I would suggest that this may be an indication of wonder (not curiosity), because, the year 1 pupils in the small stream formulating several questions/ideas did not, individually or collectively, try to answer their own questions (i.e. be curious enough to actively participate in learning). Had I intervened and given value to those questions (as Oliver suggested), then perhaps the children would have explored this natural phenomena further and T4C could have been made observable. This notion of timely teacher interventions helping to facilitate learning, is backed up by McGregor's (2008) research, this was described earlier in this thesis (section 2.2-B.1.1.1). Therefore, if my line of thinking is correct, when the year 1 pupils were playing in the stream and expressing their wonder, a mutual exploration of scientific phenomena could have occurred, and together the children and I could have conceived questions, about the apples, such as those relating to plant growth, variation and the changing seasons. Thus the category of *valuing questions,* I feel, will need to go further than Oliver's description of just valuing the questions raised by the children, if TC and T4C is to be observed. For this to occur it will need to consider both teacher mediation and child exploration. The definition therefore should take into account both the teacher and/or pupils when they both *raise and identify scientific questions.*

2.2-B.2.1.8 Modelling explanations

Through modelling explanations the teacher should, according to Oliver (2006:32), encourage children to notice relationships between the scientific and what is already familiar. Oliver suggests using a simple real life demonstration (e.g. rubbing hands together and noticing the increase in heat). Davies and McGregor (2017:24) offer other examples such as, 'pulling the bristles of two hairbrushes against each other to help children understand friction' or, role-playing 'the relative movements of the Earth, Moon, Sun and planets' (*ibid*). Whilst offering these suggestions places the focus on the teacher initiating and resourcing the activities Oliver (2006) states that they can, '[put a simple] picture in their [the pupils] heads [which] will go some way to enable connections between theory and practice' (*ibid*:32-33).

Oliver (2006) goes on to describe how the teacher should use *simple* language, to support modelling and visualising the scientific, but states that the dilemma faced by teachers '…is to give an explanation which is accurate and will not confuse the learner' (*ibid*:32). This reportedly requires '…expert science knowledge coupled with the ability to present information at an appropriate level' (*ibid*). I believe that this is a reference to Shulman's (1986) pedagogical content knowledge (PCK). Shulman describes PCK as:

> '…the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that make it comprehensible to others' (*ibid*:9).

However, this does not describe how the science is clearly explained through the chosen demonstration and/or analogy. Despite this Oliver went on to propose that this practice would train the child's mind because '[t]he child's mind needs to be trained to accept new schemas and patterns of thought' (*ibid*:33). This phraseology might suggest that Oliver, whilst recognising the need to incorporate the child into their own learning, had not actually appreciated how individual children would subjectively understand these scientific links. Davies and McGregor (2017:23) appeared to have tried to temper this somewhat by stating that modelling explanations was about 'find[ing] ways of presenting science [so] that children can access [it] in as many ways as possible' (*ibid*) because each child has an individual 'learning style' (*ibid*).

The main focus of this category is arguably on the actional/visual presentations of science (the modelling) and not the scientific explanation. In essence then, modelling explanations is about *providing opportunities to develop a relationship between the scientific and what is already familiar, through everyday phenomenon and analogies.*

<u>2.2-B.2.1.9 Encouraging autonomy</u>

When considering encouraging autonomy Oliver recommended that the children could learn through an activity which allows them to make decisions whilst they explored and played independently of the teacher. She suggested that this could be supported by '…offer[ing] a degree of autonomy to the learner' (Oliver, 2006:34) but '[t]he degree of autonomy fostered will depend on the confidence and ability of the child to pursue ideas' (*ibid*). This may be suggesting that some children have an innate ability to generate more ideas than others (i.e. be more creative).

However, unlike Oliver's explanation of this ninth category, Davies and McGregor's (2017) description involved teacher mediation. They stated that the teacher should '…begin to 'let go' of activities once children have developed the skills – both social and scientific' (*ibid*:24). This is akin to Brown and Ferrera's 1985 description of Vygotsky's ZPD (see section 2.2-B.1.1.2), where independence is gradually given as experiences (with the activity and the more capable other) increase. This description is in conflict with Oliver's definition, because Oliver believed that '[i]nterventions can actually deter the learner from pursuing ideas and taking ownership' (*ibid*:34). Thus to incorporate both explanations, for the purposes of examining survey data, I shall interpret encouraging autonomy as involving both teacher mediation and child-led discovery, that is, learners will be encouraged by the teacher to *make decisions, whilst exploring and playing independently.*

2.2-B.2.1.10 Allowing for flexible beginnings

Davies (2011) and Davies and McGregor (2017) do not attempt to reconceptualise or describe this tenth category, and the reasoning behind this is not outlined in their writings, so I turn to Oliver's description. Her explanation of allowing for flexible beginnings states that: *the autonomous meanderings of children are never wrong, but* unlike her description of *encouraging autonomy* she claimed that *the intervention of the teacher would be required* (Oliver, 2006:34). Davies and McGregor had previously considered the necessity of incorporating the teacher's mediatory practices within the previous (ninth) category; perhaps then, this is why they chose not to examine this tenth category. For the purposes of this study I have chosen to employ Oliver's original description of this tenth category (see *italicised* definition above).

2.2-B.2.2. Summary

Having considered these ten ways to make science teaching creative with Davies's (2011:14) description of creative teaching in mind, I have become increasingly aware of the potential to develop an unintentional false dichotomy between TC and T4C (Craft, 2005). By recognising the possibility of unconsciously creating this divide, just by continually referring to these practices, I have become concerned that Oliver's ten ways to make science teaching creative could also be inadvertently projected as ten distinctive characteristics of a teacher's practice. This is not my intention. Davies (2011:22) stated that these ten categories were '…not exhaustive, [and that] many teachers will recognise them as aspects of self-evidently good practice to which we [as teachers] aspire'. Here Davies is referring to them as parts (or features) of something greater, more complex, he is indirectly referencing something Ken Robinson said. Robinson (2011) stated that developing 'creativity was a multifaceted process…[which] involves many ordinary [perhaps everyday] abilities and some specialised skills and techniques' (*ibid*:49). By suggesting this I am endeavouring to highlight how these qualities are part of a richer tapestry of interweaving parts.

2.2-B.3.1 Introducing a teaching continuum

To contemplate the complexity of creative teaching further (or from a different perspective) in this section of this literature review I will reflect upon four teaching theories (i.e. behaviourism, constructivism, social-constructivism and socio-culturalism). I will consider how far they provide increasing opportunities for the children to be subjectively creative (and articulate) through scientific knowledge, as set out by the National Curricula (DfE, 2013b).

2.2-B.3.2 The teaching continuum (through four teaching approaches)

As well as clarifying the nature of the four teaching approaches mentioned previously it is my intention to help place into context each of the three teaching practices mentioned throughout the literature review (expositional, TC and T4C). This is not an attempt to distinguish these three practices as distinct methods of teaching but a means to try and associate them with current teaching theories.

<u>2.2-B.3.2.1 The behaviourist approach</u>

It was suggested by McGregor (2007:61) that the behaviourist teacher does not take into account the mental activity or abilities of the child, because learning is focused on performance and not cognitive manipulation of ideas or concepts. So the practitioner celebrates perfected behaviours and performances in order to conclude that there has been a successful completion of learning outcomes (I associate these specific objectives with the statutory requirements found within the Science curricula). Thus, whilst I have previously stated that the behaviourist approach was akin to an expositional teaching practice (see section 2.2-A.5.1) I do not envisage the behaviourist teacher passively transferring information in a unidirectional manner (akin to Alexander's instructional and rote teacher talk), for it is important to acknowledge that the behaviourist teacher also assesses a child's learning (through recitation) (*ibid*). As I stated above, they do this so that they can obtain evidence that learning objectives have been met (McGregor, 2007).

The teacher who chooses to adopt this approach can also demonstrate a scientific phenomenon (e.g. static electricity) in an unusual and fascinating way (e.g. by making hair stand on end via the use of a Van de Graaf generator). They could also choose to use an everyday object to enable the children to look at the same science from another angle (such as using a balloon to produce the same effect as the Van de Graaf). Both these teacher-led experiments could go on to pique the children's interest and this would arguably be classified as an imaginative, interesting and exciting science lesson akin to TC (NACCCE, 1999; Davies, 2011). Having personally been in the presence of approximately 30 primary aged children and observed their reactions when both of these experiments have been performed, I know that these demonstrations can raise exclamations of 'wow!', but whether it generates a desire for the pupils to want to personally understand the science behind the activity is unknowable without further consultation with the pupils themselves (Schmitt and Larhoodi, 2008).

<u>2.2-B.3.2.2 Constructivism</u>

McGregor (2007:62) states that unlike a teacher promoting behaviourist learning, a constructivist recognises that children are agentive and learning is more than just a performance. McGregor suggests that the teacher who chooses to facilitate constructivism values their pupils' thinking and seeks evidence of learning through prescribed reflective tasks which could be performed creatively through appropriate challenging, problem solving activities (akin to the NACCCE's description of TC).

To illustrate this type of teaching approach I include a brief description of a plenary I witnessed, which took place at the end of a year 6 carousel lesson. Prior to this plenary, during the actual lesson groups of four/five children were invited to consider the science behind six separate scientific investigations. These were all based on changing states of matter. They were: breathing on mirrors, dissolving salt in water, making water prints on slate, lighting a candle, boiling a kettle and making a miniature water cycle in a glass jar. During the final question and answer phase of this lesson the teacher invited one child to consider their own subjective thoughts regarding what happens to wax when a candle flame is blown out. The child's response appeared to draw from his own experience of observing water solidify, he stated, *'…it freezed up'*. The teacher seemingly accepted this alternative understanding, but then asked him, in a soft, warm and calming manner, to consider his idea further, when she asked, *'Would you like to change a little bit of what you've just said? Did the wax freeze?'*. This question was followed by a moments pause and then the boy said: *'It hardens'*. She congratulated the pupil and continued to question the rest of the class. This constructivist teacher (although wonderfully calm and caring) facilitated the articulated thoughts of the child towards a specific response, through reflective questioning, but without further interactions I cannot be sure that the child understood how various substances required different temperatures to solidify (and this was no different to water freezing).

<u>2.2-B.3.2.3 Social constructivism</u>

As stated previously in section 2.2-B.1.1.2 Vygotsky (1978) suggested that the learners cognitive development occurs in a zone between what they are capable of doing for themselves and what they are only able to do with the help of others (e.g. a teacher). This description is the back drop (or spirit) of the social constructivists approach to teaching. I will endeavour to put this teaching practice into context through the critical examination of a child-child verbal exchange. This interaction occurred during the same year 6 carousel science lesson, as described in the previous section (2.2-B.3.2.2).

During this science lesson I was listening in to one group of four boys who were observing salt dissolve in warm water. One of the boys asked: '*How did the salt dissolve?'.* A discussion followed whereby they cumulatively accepted and agreed that the salt and water particles combined to make salty water. Then one thought more divergently and called out, *'Keep mixing it! See if they [the salt] reappear!'.* Immediately after this a second pupil exclaimed: *'If you evaporate the water the salt will reappear'.* This was enthusiastically challenged when another boy thought that it could reappear if they simply continued to stir the solution, because*: 'The boiling water will dissolve because we mixed it'.* A fourth boy, who had been leaning backwards on his chair placed all four chair legs flat on the floor, and confidently stated that: *'If you heat up the water the water condenses'*. It was then that everyone appeared to mutually agree with this idea. Just from this small extract it is possible to see the back and forth exchange which reached for a final agreement.

However, whilst the children felt able to reveal their alternative predictions about what could happen, I do not feel the conversation goes far enough to reveal the boys understanding of the science behind the condensation of water. I turn to McGregor (2007:62) who deliberated upon the possibility that the teacher (Vygotsky's more expert other) could have further facilitated their learning, and through teacher-child exploratory interactions could have questioned more to illuminate whether or not the boy knew (or understood) that the water would need to cool down first before it condensed. If these understandings were reified through these verbal exchanges it could have illustrated a more social-constructivist to learning providing the children with the opportunity to express and explore their own subjective thinking (T4C). McGregor (2007:62) referred to a social-constructivist teacher as one which is more 'interventionalist'. This, according to Cremin *et al* (2013:16) would require a certain amount of risk-taking on the teachers' part, for they would need to be willing to draw from and challenge different contexts (i.e. their pupils' own subjective viewpoints, such as the salt reappearing simply by stirring the solution) to construe and reach for a scientific understanding.

<u>2.2-B.3.2.4 Socio-culturalism</u>

The socio-cultural perspective reportedly arises when thinking and actional learning processes occur naturalistically (to the mutual benefit of all) through active participatory practice (McGregor, 2007:63). McGregor indicates how this approach to learning is more akin to apprenticeship (*ibid*). This was described by Rogoff (1995) as:

> '…a concept [that] goes far beyond expert-novice [or teacher-student] dyads; it focuses on a system of interpersonal involvements and arrangements in which people engage in culturally organised activity in which apprentices become more responsible participants' (*ibid*:143).

This notion of apprenticeship resonates with Alexander's (2010:247) description of the learners serving as resources and challenging each other. This mutual sharing of on-going thoughts and ideas, Joubert (2001) postulated, encourages children to take the initiative actively, instead of merely learning to imitate the teacher. The purpose here, as McGregor (2007:63) highlighted, is not to arrive at the 'correct' answer but to enable agentive learning through collective endeavours which will, in turn, immerse the children in their own learning. This personally owned practice, Warwick and Dawes (2013) believed, can make tangible, for observation by the teacher, the construction of 'new meanings, explanations, hypotheses, arguments and procedures' (*ibid*:51); that is, the child's critico-creative practices could be revealed independently of the teacher.

2.2-B.3.3 Summary

In summary, expositional teaching was associated with adopting a behaviourist approach, and depending on the activity (if it had the potential to pique the children's interest) could also be considered to be TC. Constructivist and social-constructivist approaches could also be TC, however, if the latter of these two stances were mediated appropriately through the child, via the teacher I propose that this could theoretically also illuminate T4C. The increasing opportunities for the children to be creative and express their own ideas through these three teaching practices, is graphically illustrated in figure 2.2 below.

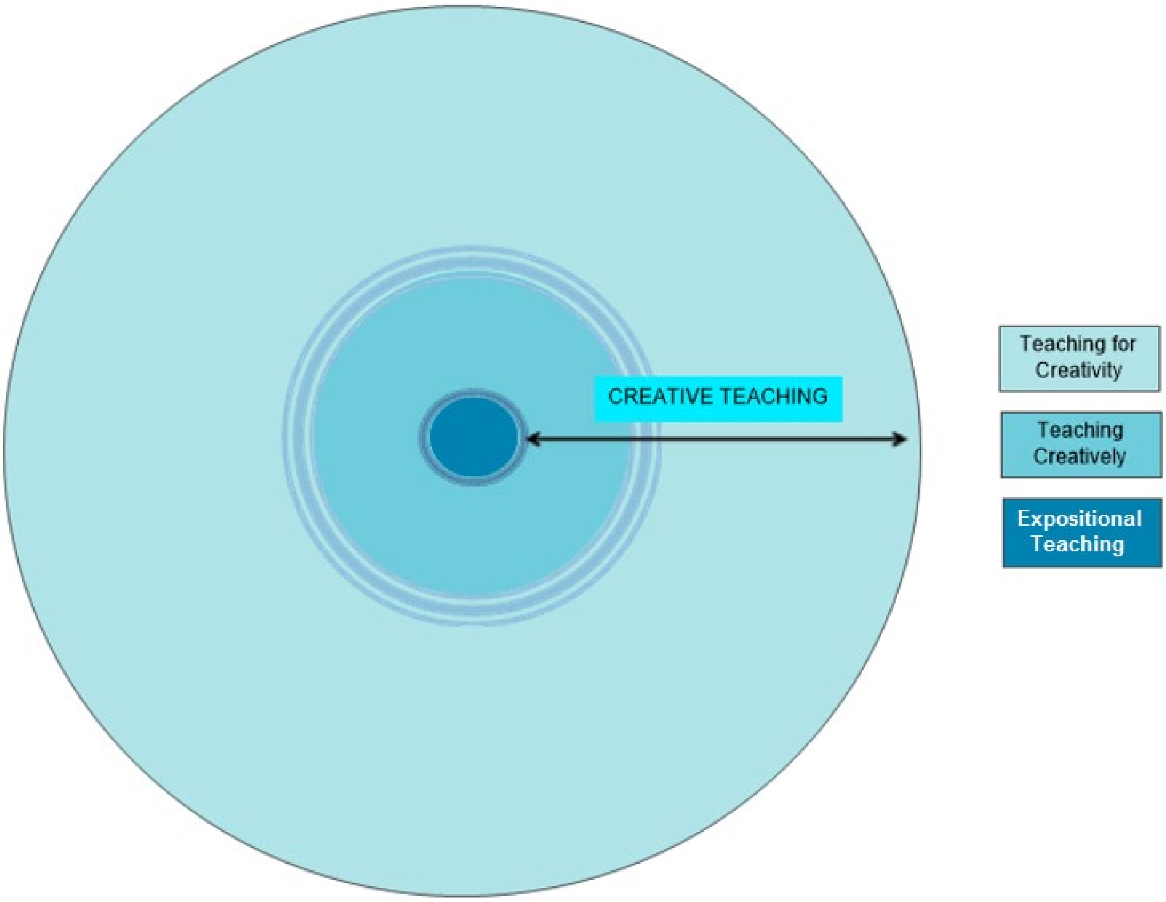


Figure 2. 2: A diagram to represent the increasing opportunities for developing creativity through three teaching practices (expositional, TC and T4C)

In figure 2.2 the transitions between each teaching practice is represented by the striated circumferences, and the increasing opportunities for the children to develop and express their thinking through the teaching approaches (i.e. expositional, TC and T4C) is visualised via the increasing cumulative areas of each circle.

It is intended that the three teaching practices (expositional, TC and T4C), as described through three teaching approaches (behaviourism, constructivism and social-constructivism) and illustrated via figure 2.2, will lend themselves to a generalisable structured teaching schema, (see methodology, sections 5.6.2.4 – 5.6.2.5, for a further description of its development). It is my aim to employ this schema to characterise how (and when) individual teachers provided opportunities to foster creativity.

You may notice that I have not associated the socio-cultural approach with either of the three teaching practices. This is because, I suggest, that the pupils, when they have undergone the apprenticeship are autonomous critico-creative learners. Thus the teacher would not be present as a fixed mediator and characterisable features of their practice will not be tangible.

Having considered how creativity could be promoted through the teachers' practices, I have not discerned how it could be captured and assessed. Davies (2011) and Oliver (2006) highlighted Assessment for Learning (AfL) as a potential tool to formatively judge on-going creative development. This practice will be described further in the following chapter.

Chapter 3

3.1 Considering assessing creativity

Having pursued a more dynamic definition of creativity (see sections 2.2-A.1 - A.3). I will attempt to appreciate how creativity might be illustrated through formative assessment. I intend to do this by initially reviewing and examining studies (section C) and theories (section D) that have proposed ways of assessing learning. In section D will also consider how (or if) expressions of creative thinking could be revealed through theorised strategies.

SECTION C

In section C I will be seeking to understand why (and how) primary school teachers assess learning in science. This will be accomplished by initially examining current in-class assessment practices (see section 3.1-C.2) followed by a brief examination of how formative assessment itself is reportedly being employed by primary school teachers (section 3.1-C.3).

3.1-C.1 What is assessment?

Assessment can be either summative or formative. Harlen (2009) describes summative assessment as capturing the student's achievements at a particular time, in a specific place. This is known as assessment of learning (AoL). Whilst, according to Schofield (2011:85), formative assessment is purposeful and feeds into a learning cycle which engages the learners' in their own development. This form of assessment is acknowledged as assessment for learning (AfL).

3.1-C.2 How is primary science currently assessed?

Harlen (2012) and Davies *et al* (2014b) suggested that accepted practice for assessing primary science appeared to be mainly focused on the production of summative (final) assessments, via the use of formative practices. It was pointed out, by Harlen (2009), that these types of formative judgements can provide evidence of learning which, if not appropriately mediated, can arguably be an inaccurate gauge of the child's learning. This mishandling has been aptly surmised, in an analogy, by Wiggins and McTighe (2001), cited by Sherborne (2009)

> 'Imagine your goal is to be healthy. To assess your health you have your blood pressure measured. You discover a way to control your blood pressure by biofeedback, but continue to be inactive and overeat. Yes, you might seem all right at your next check-up, but will you achieve your goal of good health? It would have been better to follow a balanced diet and take exercise' (Sherborne, 2009:68).

The quotation above could be a good analogy for someone teaching for the sole purpose of producing a narrow, pre-specified attainment orientated result (i.e. not engaging pupils in their own learning cycle). If not mediated appropriately this type of judgement carries a very real danger of not seeing the whole truth surrounding the students' actual creative, personal capabilities. Restricting teaching practices in such a way may not suggest, to the child, a world beyond attainment and achievement levels (Crick and Wilson, 2005). Having said this, I am not trying to state that summative assessments cannot inform on-going formative judgements. Taras (2005:469) reminds us that the '…misuse of these [summative] judgements does not invalidate or minimise' their potential for an effective formative impact', but measuring the child's performance levels using summative testing methods alone will not help children understand the nature of science and/or their search for their own interpretations (Eady, 2008).

Unfortunately, at present there is still no universal agreement on which strategies and/or techniques constitute best practice for on-going formative assessment (Dunn and Mulvenon, 2009), although lists of strategies have been offered (Earle, 2014, Davies *et al*, 2014b, Earle *et* al, 2016).

3.1-C.3 How is AfL currently being enacted out in classrooms?

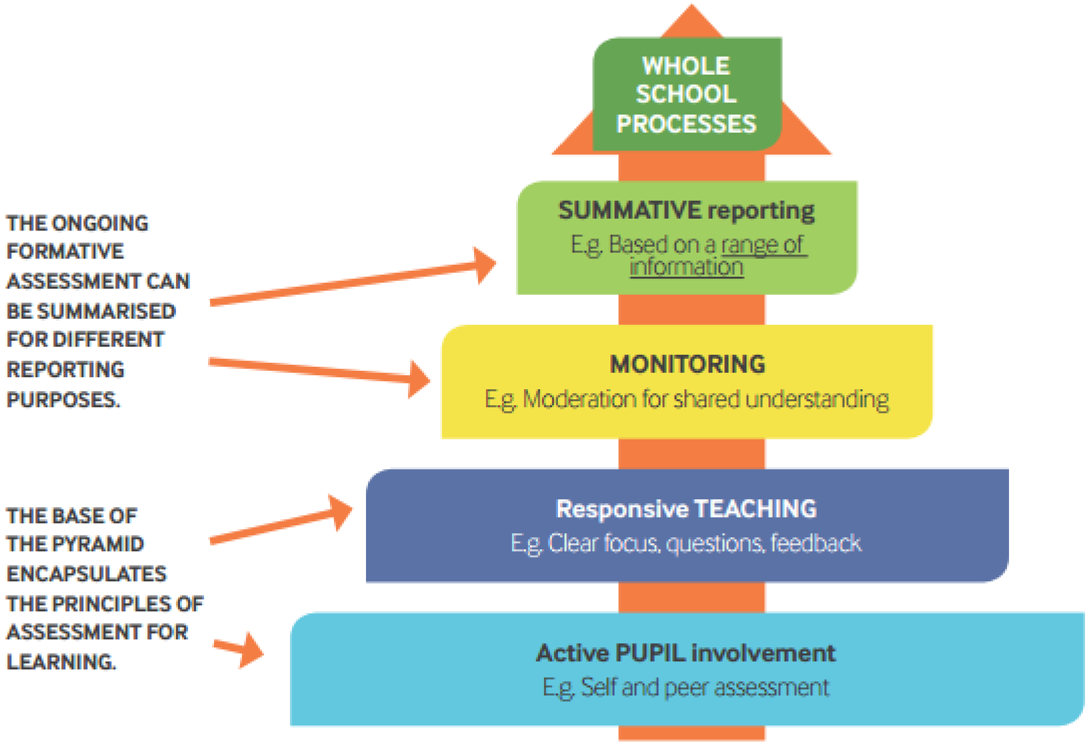
Before considering how (or if) AfL can be integrated into the science classroom, to formatively judge on-going creative development (see section D), I feel it is first necessary to appreciate the current practices of in-class AfL reportedly being employed.

To do this I turn to Earle (2014) who analysed 91 science leaders' written reflections of primary school science assessment (both summative and formative). The data-set she examined, to elucidate the list assessment strategies employed, was taken from a specified cohort of science leaders within the Primary Science Quality Mark (PSQM) scheme. The PSQM is an award scheme described in further detail in the methodology chapter of this thesis (see section 5.6.1.5). However, Earle describes it aptly here when she states:

> ‘PSQM is an award scheme for UK primary schools. It requires the science subject leader (co-ordinator) in each school to reflect upon and develop practice over the course of one year, then upload a set of reflections and supporting evidence to the database to support their application. One of the criteria requires the subject leader to explain how science is assessed within the school’ (*ibid:*216).

The data set analysed in Earle’s study consisted of the uploaded text from the criteria section described at the end of the above quotation. It was taken from the April 2012 to March 2013 cohort. These teachers’ reflections were separated into summative and formative strategies. Upon inspecting the results Earle admitted that the diverse responses (the science leaders descriptions of the assessment strategies used across the schools) had not managed to successfully capture the rich data necessary to lay claim to fulfill a formative purpose (*ibid:*221). This fulfillment of purpose, Black and Wiliam (1999) suggested, occurs when '…the [learning] evidence is actually used to adapt the teaching to meet the needs [of the learner]' (*ibid*:2). It is suggested that the data set examined had not revealed a formative resolution because the teachers’ written descriptions did not provide enough detail to describe specific episodes of children’s developing learning. Nevertheless, Earle (2014:223) still reported 18 different elicitation strategies (e.g. drama, Powerpoint presentations, concept cartoons, investigations, tests etc…) and the three most prevalent reported by the teachers turned out to be questioning, discussion and observation.

To illuminate formative assessment strategies which describe on-going learning Earle (2014:219) suggested consulting ‘The Assessment in Primary Science’ (TAPS) project. This project has developed an analytical framework (a TAPS pyramid model) which illustrates how teachers can adopt formative assessment for whole school (summative) reporting, through five interwoven but distinct layers (Davies *et al,* 2014b). Figure 3.1 below depicts these five layers, in a simplified format, and is taken from the projects most recent publication (Earle *et al,* 2017).



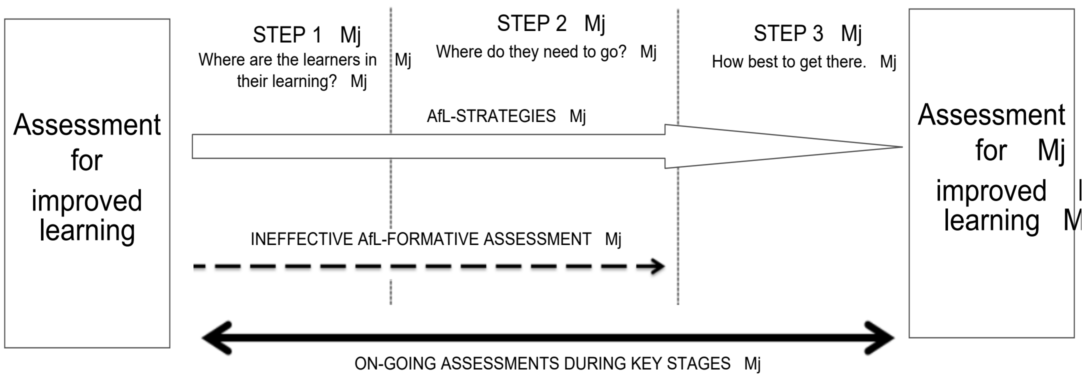
The TAPS pyramid was originally based on a whole-school assessment model developed by Wynne Harlen (2012). It is the bottom two layers; the 'pupil layer' and the 'teacher layer' which are said to have the greatest impact on progress and encapsulate the principles of formative assessment (*ibid*). In 2016 the TAPS pyramid became interactive (Earle *et al,* 2016) and can be found at https://pstt.org.uk/resources/curriculum-materials/assessment. Whilst this provides a platform to examine a wide variety of primary science assessment techniques (including mind maps, annotated drawings, KWL grids, mini-whiteboards, post-it notes and even the children assessing their own and others work) alongside specific examples of the children's actual in-class workings, I find myself drawn to Davies *et al* (2014b) when he implied that the static reification of these elicitation strategies would still not provide enough evidence of the actual on-going developmental learning needs of a child. Thus broader data is still required to understand how successful these strategies are in elucidating on-going learning.

SECTION D

In section C the employment of formative assessment strategies, as reported by the PSQM and TAPS, was briefly considered. Current descriptions of in-class formative assessment in science indicated that broader evidence is required to reify how successful these strategies are in understanding the on-going learning needs of individual children. In the following section my focus will be on eminent academics' theorised descriptions of AfL whilst simultaneously deliberating upon whether creativity can be reified through them.

3.1-D.1 How can 'effective' AfL be enacted out in classrooms, according to theory?

For AfL to be utilised as a potential tool to assess on-going learning (and potentially creativity) in the science lesson it has been suggested that attention should be paid to ensuring that it is not subverted by the integration, misinterpretation and inappropriate use of standalone AfL-formative assessment strategies (such as those described in section 3.1-C.2). Black (2012:130) believed this approach will fall short of an effective review of children's on-going learning, he goes on to suggest that a more appropriate approach is achievable in three steps (these are represented in figure 3.2).



**adapted from Black (2012)*

Wiliam (2011:45-46) proposed that Black's three key steps in figure 3.2 involved three parties, they are: the teacher, the students and their peers. He also suggested that crossing the three kinds of individuals with the three key steps would produce five 'key strategies' of formative assessment. To elucidate whether these five strategies effectively fulfil a formative purpose and illuminate creativity-in-learning I examine them in the following section.

3.1-D.2 Wiliam's five 'key strategies' of formative assessment

Wiliam (2011) proposed five 'key strategies' of formative assessment are:

> 1. 'Clarifying, sharing and understanding learning intentions and criteria for success
> 2. Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning.
> 3. Providing feedback that moves learning forward.
> 4. Activating learners as instructional resources for one another.
> 5. Activating learners as the owners of their own learning.'
>
> (*ibid*, 2011:46)

These five key strategies are examined in further depth below.

3.1-D.2.1 Clarifying, sharing and understanding learning intentions and criteria for success

The first of these key strategies: 'clarifying, sharing and understanding learning intentions and criteria for success', Wiliam implied, belonged to the teacher initially (Wiliam, 2011:46), the children reportedly becoming involved with the process through reflective activities (*ibid*). This is rather like Blanchard's (2003:260) suggestion that the lesson's objective (and perhaps the success criteria) was initially the teacher's responsibility but that during the lesson the children took personal ownership of it. Nevertheless, whether this occurs (or not) I had earlier, in chapter 2, proposed that having a set purpose, such as the learning objective, would limit the numerous possibilities that creative thinking might unpredictably proffer (see section 2.2-A.3.2) and Wiliam even appeared to agree when he stated:

> 'Not all students have the same idea as their teachers about what they are meant to be doing in the classroom. For a simple example, we might ask students which is the odd one out in the following list of objects: knife, fork, hammer, bottle of ketchup. Some students will say that the bottle of ketchup is the odd one out, because the others are all metal tools. Other students will say that the hammer is the odd one out because the other objects can be found on the kitchen table at mealtime. Of course, in an absolute sense, neither of these two answers is better than the other, but as Nell Keddie

(1971) pointed out years ago, schools place a greater value on the first way of thinking about the world than the second.' (Wiliam, 2011:52)

Whilst the strategies described in the above example enabled the children to freely express their creative ideas between each other (interpersonally) Wiliam is implying that having a learning objective, such as the use of a preferred scientific convention, could restrict divergent thinking (de Bono, 1992) and temper creativity.

3.1-D.2.2 Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning.

The second key strategy focuses on the teacher meeting the learners' needs by 'engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning' (Wiliam, 2011:46). This is described with more clarity when Wiliam states that 'with careful planning and the thoughtful application of techniques…the teacher can make the classroom a much more engaging place for students and one in which the teacher is able to make rapid and effective instructional adjustments to meet the learning needs of all students' (*ibid:*104-105). This description is akin to Black and Wiliams (1999) description of purposeful formative assessment, as outlined in section 3.1-C.3, but as I had also previously stated simply eliciting evidence of learning through the application of formative assessment activities would not, on its own, provide enough detail to elucidate the actual on-going developmental learning (or critico-creative practices) of a child (Davies, 2014b).

3.1-D.2.3 Providing feedback that moves learning forward

The third key strategy for formative assessment suggests providing feedback to move the child's learning forward. Wiliam (2011) states that 'to harness the power of feedback to increase student learning.... It should be focused [and] it should relate to the learning goals that have been shared with the students' (*ibid:*132). I would argue that this explanation is akin to Sternberg's (2003) forward incrementation model of creativity, whereby the field moves in the direction it was originally going to head anyway (i.e. towards the learning objective), thus there is a predefined set purpose and as I have previously suggested this can be seen as a restraint when developing creativity (see section 3.1-D.2.1).

3.1-D.2.4 Activating learners as instructional resources for one another

Wiliam (2011:46) then went on to suggest 'activating learners as instructional resources for one another' as the fourth key strategy. He stated that this type of cooperative learning could enable children to think more carefully and conscientiously together (*ibid*:133). However, he also goes onto say that when working together the learners will be '…forced to internalise the learning intentions and success criteria but in the context of someone else's work' (*ibid*:144). This projection of a mandatory outcome and the description of internalising these set goals arguably envisages the learner as a passive receiver of knowledge (Bredo, 1999:28) which unfortunately separates the learner from their surrounding social environment (i.e. the teacher and their peers) and thus leaves limited room for the articulation of subjective creative thoughts (Rogoff, 1995:156).

3.1-D.2.5 Activating learners as the owners of their own learning

In the fifth strategy Wiliam (2011:158) stated that '[t]eachers have a crucial role to play in designing the situations in which learning takes place, but only learners create learning', and by activating the pupils they will be '…able to manage their [own] learning' (*ibid*). It could be argued that this envisages the child as if they were a lone scientist learning from their surrounding world, post teacher initiation. This is akin to Piaget's constructivist theory which omits the socially constructed aspects of development, and it is these interactional exchanges which are, according to section 2.2-B.1.1.2, integral when trying to reify creativity-in-learning.

3.1-D.3 Summary

From the examination above it becomes evident that Wiliam's five key strategies of formative assessment can provide ample scope for students to contribute to their own formative learning, however the social element of these interactions appear limited (especially when the learners become owners of their own learning). Additionally, Wiliam appears to suggest that learners should be guided towards set scientific learning goals and it is these types of purposeful interactions that I have previously argued limit the ability to think creatively (section 2.2-A.3.2). It is therefore suggested that these five key strategies (as they are described above in my literature review) will not go far enough for the children's creativity-in-learning to be illuminated. Nevertheless, it is still my intention to keep these five key strategies in mind when examining reported AfL techniques (see chapters 6 and 9). I do this to begin to understand how enactments of formative assessment are currently being perceived and practiced by teachers in their science lessons.

To contemplate how creativity-in-learning may be naturalistically embedded in the classroom I am led towards considering what it may look like in the primary science classroom. This will be discussed in the next chapter where it is my intention to argue and define varying types (or degrees) of creativity in order to elucidate the nature of its characterisation and expression within the primary school setting.

Chapter 4

Developing a proposed model of creativity

SECTION E

It is now my intention to define varying types (or degrees) of creativity. These gradations can be found within many different learning contexts. I will endeavour to exam and synthesise different theories (and ideas) into a model, so that I can begin to appreciate how creativity can naturalistically emerge from within the primary school classroom setting.

4.1-E.1 Examining little-c creativity

To begin describing these gradations of creativity I will first examine Craft's (2001) concept of little-c creativity. An example of this type of creativity (i.e. everyday 'what if' problem solving) can be found in section 2.2-A.2. This involved a year 6 pupil who found fault with a nine volt battery when trying to create a series circuit. Here the girl exemplified an openness to other possibilities (or solutions), for whilst other batteries were available at the front of the class she opted to try and recharge it (albeit unsuccessfully) with static electricity by rubbing it on the carpet. However, Craft's description of little-c creativity does not distinguish between the hard working professional adult (perhaps a professional scientist) solving an issue at hand and a primary school child trying to understand/solve their current predicament. Thus, Kaufmann and Beghetto (2009) postulated, it would be necessary to make further distinctions to this concept because it would be unfair to compare the everyday creativity of an eminent scientist with that of the year 6 girl trying to recharge the nine volt battery.

4.1-E.2 Little-c and mini-c perspectives of creativity

If the girl with the nine volt battery had independently followed Sternberg's (2003) reconstruction model of creativity, as I depicted through Sawyer's (2012) eight stages (see section 2.2-A.3.2), this type of cognitive development, Beghetto and Kaufmann (2007:76) stated, could be called 'mini-c creativity' (instead of little-c creativity).

In the classroom interventions from the teacher could have an effect on the child's mini-c; Beghetto and Kaufmann (2007) made a reference to how the adult's involvement could affect a child's creative endeavour when they considered feedback.

> 'If a student…is given feedback based on standards that are too harsh, she will not pursue creative activity. If a student… is given feedback that is not harsh enough (with little attention to any semblance to real-world standards), the results can be as potentially devastating as if received no support. He will never learn to grow and expand his creativity. The goal, just as Goldilocks sought oatmeal that was neither too warm nor too cold, is to provide the right level of feedback. There is a delicate tightrope between over encouraging a student and not encouraging them enough' (*ibid:77*).

These interventions, made by the teacher (or the more able other), are examined in more depth in the following sections.

4.1-E.3 Movements between mini-c and little-c

According to Beghetto and Kaufmann, the nature of the learning experience moves between the intrapersonal and the interpersonal via 'ideational-code switching'.

> 'Ideational-code switching refers to the ability to move between intrapersonal creative interpretations (mini-c) and interpersonal expressions of creativity (little-c). Like linguistic code-switching (in which multilingual speakers move between a dialect and standard form of a language when recognizing that their dialect is not being understood), ideational code-switching highlights the need for individuals to receive cueing from their social environment when their ideas and contributions are not understood' (Beghetto and Kaufmann, 2007:77).

This is akin to Vygotsky's (1978) law of development when he stated that:

> 'Every function in the child's cultural development appears twice: first on the social level, and later, on the individual level: first between people (interpsychological), and then inside the child (intraphychological). This applies equally to voluntary attention, to logical memory and to the formation of concepts' (ibid:57).

However, Vygotsky's law only travels in one direction from the interpersonal (little-c) to the intrapersonal (mini-c), whereas ideational-code switching moves back and forth between the two.

This movement brings to mind the year 2 child, first mentioned in section 2.2-A.3.2, who combined two distinct ideas or ways of thinking through Sternberg's model of integration. She imagined two people swapping places in a room as an analogy for the earths' rotation around its axis in order for her to cognitively capture the scientific notion behind day and night. She initially considered this to be a silly idea and was reticent to express it initially. However, after I prompted her (or cued her) to tell me by saying *'let's decide together if it is, as you say, silly before we tell teacher'*. She revealed her integrated analogy and I informed her that I thought it was '…*a lovely way to think about it'*. She was so proud of her idea being quietly and confidentially praised that this usually shy girl put her hand up during the plenary to read out her idea aloud. It was evident through this interaction that the child had intrapersonally understood the scientific concept, but before speaking to me on an interpersonal level, she had not wanted to personally take ownership of it.

These movements between mini-c and little-c required to transform the girl's understanding could consist of what Bruner (1966:27) called 'spurts and rests'. Bruner stated:

> '…mental growth is not a gradual accretion, either of associations or of stimulus-response connections or of means-end readinesses or of anything else. It appears to be much more like a staircase with rather sharp risers, more a matter of spurts and rests. The spurts ahead in growth seem to be touched off when certain capacities begin to develop. And some capacities must be matured and nurtured before others can be called into being…some environments can slow the sequence down or bring it to a halt, others move it faster. In the main, one can characterise these constrained sequences as a series of prerequisites. It is not until the child can hold in mind two features of a display at once, for example, that he can deal with their relationship…' (*ibid*:27).

Bruner is attempting to try and outline development through linearised back and forth movements, and the reference to holding two features in the mind at once is indicative of the year 2 child undergoing Sternberg's (2003) integration model of creativity (see section 2.2-A.3.2). We must also consider how the cognitive process itself, according to Rogoff (1995:151), is referred to as '…active and dynamically changing…' implying more of an amorphous topology which is consistent with Sawyer's (2012) fluid conceptualisation of creativity rather than Bruner's description. This would also imply that all participants interact with the creative process in unique and unpredictable ways.

4.1-E.4 Varying communities of learning: the middle-c

These unique pathways described above are important when considering each individual pupil, an example could be those who may be perceived as more scientifically able. I have one year 2 boy in mind when I consider this.

On a school trip to 'the living rainforest', a year 2 boy sat next to me to eat his lunch. Three other boys sat on the same table and started to talk about a new movie set out in space. Suddenly, from out of nowhere the year 2 boy in question said to me, *'Did you know that stars are made of gases?'. 'Really!'* I replied. '*Yeah!'* He exclaimed. He jumped up off his seat and started waving his arms around. *'All stars are made of gases'*. His volume control had at this point risen to enthusiastic levels. He stated: *'These gases they bang and crash together and make new gases'*. He jumped into the air and clapped his hands together enacting out the gaseous explosions. *'Well that's impressive!'* I exclaimed. I then said: *'Is it me or do you know more than you let on?'.* I smiled at him hoping he would say more but he just sat back down with a satisfied grin on his face. Four months later I was walking home when I met his mother, and we started talking. I eventually felt at ease enough with her to say that her son seemed to know a lot about science. She appeared rather hesitant to answer and then said *'Yes, yes he would'*. She paused. *'Both me and my husband and I have BSc's and whenever there's an opportunity we explain things to him. For example if we're bathing him we'll explain why the water level raised etc…'*. Suddenly it was easy to recognise where his scientific knowledge had arisen from, that is, the everyday social experiences with his parents.

I convey to you this story because, as Craft (2008) recommended, when developing creativity it requires the teacher to recognise what has been before, that is, each individual's existing social, cultural and historical background (Beghetto and Kaufmann, 2007). Rogoff (1995) concurred when she argued that the sociocultural background of each individual will contain experiences from within numerous varying communities:

> '[The sociocultural background of each learner includes]…the activities of their community, [where they engage]…with other children and with adults in routine and tacit as well as explicit collaboration (both in each other's presence and in otherwise socially constructed activities) and in the process of participation become prepared for later participation…' (*ibid*:139).

The proposed future participation described at the end of Rogoff's quotation could arguably be an example of mini-c creativity when something has been learnt afresh within a new context within a specific environment (e.g. in conversation with their parents as in the case of the year 2 boy, or in the primary school science classroom, just like the year 2 girl).

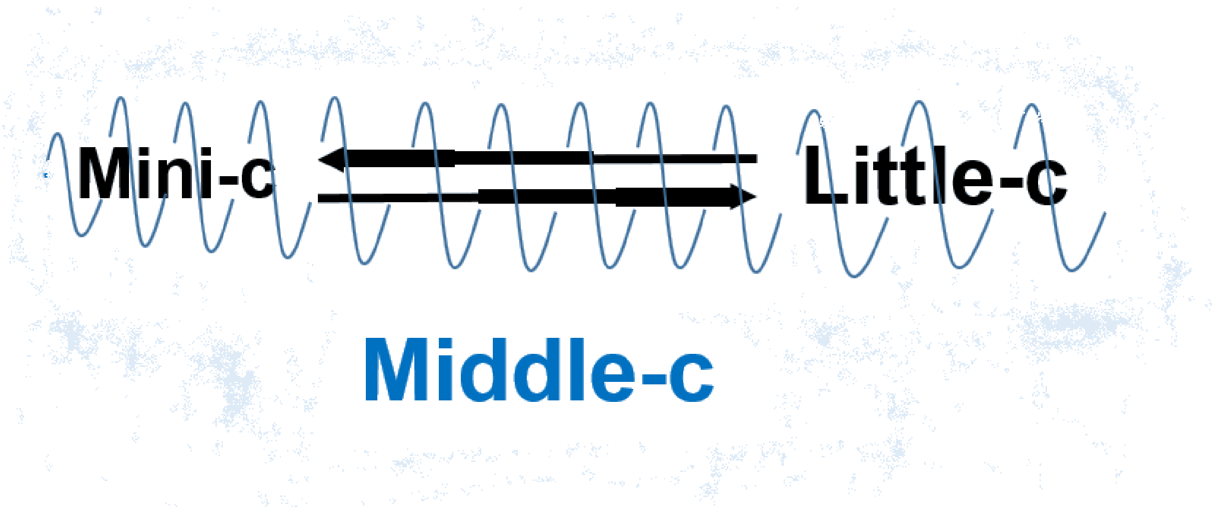
Creativity then, in the primary school science classroom, Craft (2008) recommended, must be recognised as both a personalised endeavour (as seen through the lenses of each child's prior personal experiences) and through the present community in which its development is taking place. This, it is argued, is similar to my interpretation of appreciating creativity in the classroom environment, through an understanding of both of Sawyer's (2012) individualist and socioculturalist standpoints (previously described in section 2.2-A.2). Craft labeled this creativity which encompasses the past and present social planes of the individual(s) 'middle-c' creativity (Craft, 2008).

4.1-E.5 Summary

In summary the mediatory practices of the practitioner may, if appropriately handled through the middle-c (through the mutual collaboration between the primary school's ethos, the participation in classroom interactions and the individual learner's experiences) can augment creative development. This, according to the examination of the theories above, requires that ideas are offered and exchanged interpersonally by the child (little-c) in order for it to be intrapersonally transformed (mini-c). Having considered this I have gone on to proposed a model of creativity.

4.1-E.6 Proposing a model of creativity

It is proposed that the child's creativity can be developed through verbal exchanges about scientific ideas with others. I have described this as fluctuations between mini-c (the intrapersonal) and little-c (the interpersonal) through the middle-c (the participation in interactive exchange within the classroom environment). This is illustrated in figure 4.1 below.



The bidirectional movements (or the ideational-code switching) between the intra (mini-c) and interpersonal (little-c) expressions of potential creativity is represented through the black anti-parallel arrows. The increase in width as the black lines progress towards the arrow heads are indicative of the possible/probable development of subsequent ideas as children articulate what they think. The sharing and exchange of views and thoughts I have represented as linear arrows illustrating back and forth movements indicative of Bruner's (1966) spurts and rests and Sternberg's (2003) integration model of creativity. However, Sawyer (2012:91) suggests that the extent of creative thinking is shapeless and exists as an undefined topology; thus the arrows' pathways represent the potential development of original ideas, propositions and suggestions but the nature of the connection between the mini-c and little-c is unpredictable. This amorphous nature of creativity is highlighted further through the light blue fuzzing which surrounds the proposed model. The past and present social and cultural interactions between participant learners contribute to 'middle-c' creativity (Craft, 2008) and this is represented by the blue corkscrew on figure 4.1. Note how the corkscrew increases in diameter marginally as it moves from the mini-c to the little-c. This is representative of the extent to which the expressed ideas are more likely to flourish through interpersonal exchanges (than solely intrapersonal thoughts).

I argue that this proposed model (i.e. figure 4.1) is a theorisation of the influence of interpersonal exchanges on the nature of the development of creativity in the science classroom and a simplified view of the way interaction can affect creativity. This model has been adopted to inform the way I am 'looking' at how creativity can be nurtured within a primary science lesson.

4.1-E.7 Chapters 2-4: an overview

Thus far I have highlighted how policy imperatives have hidden the need to develop creativity in science away from the main text which deals with the actual curriculum to be taught (section 2.2-A.5). Nevertheless one document championed developing creativity through creative teaching (NACCCE, 1999). This approach is composed of two teaching practices: TC (where the focus is on the teacher) and T4C (where the development of creativity is through the child). Jeffrey and Craft (2004) reported that T4C could occur spontaneously when TC, and Davies (2011) highlighted how they must not be considered distinct or mutually exclusive. The issue therefore is not which teaching approach is best, but to what extent are there opportunities for developing creative thinking through these composite parts of creative teaching. Since the NACCCE's publication only some of its language has been adopted, e.g. the Rose (2009) review referring to *TC* and *thinking creatively*; I have suggested that this lack of reference could be indicative of another issue emerging in education, that is, the promoted drives (attainment and performance) behind the curriculum not sitting well with creative teaching. To try and highlight how both the NC and creative teaching can be mutually beneficial, when developing creativity, I have considered how the NC can be delivered through three teaching approaches, they are expositional, TC and T4C (section 2.2-B.3.2). I will attempt to employ these reflections to observed science lessons, as a means to uncover and illustrate observable key features of teaching (see chapter 7), which reportedly can support and promote opportunities to be creative during a science lesson.

Having earlier on in this thesis reviewed several characteristics of creativity (section 2.2-A.3), I synthesised a definition of creative thinking, which was: '*the formation of all possibilities and fresh concepts that are original and useful to their creator'.* For this to be given form in the science classroom I have considered how teachers can provide opportunities to promote creativity-in-learning through ten ways to make science teaching creative (2.2-B.2.1). These will be considered, as I attempt to explore teacher's perceptions of their creative teaching, during science lessons. (see chapters 6 and 9). Whilst I have provided descriptions of how these ten ways can illuminate moments of creativity (e.g. via Sternberg's integration and redefinition), I have ultimately proposed that, it could be the verbal exchanges between classroom participants that may be able to reify creativity-in-learning (section 2.2-B.1.1.2) and these interactions can only be elucidated through examining the video and transcripts of science lessons (chapter 8).

It was also noted that the literature surrounding creative teaching had not provided a criterion from which to judge the on-going development of creativity (Oliver, 2006). Davies (2011) suggested formative assessment so I have chosen to examine the teachers AfL assessment strategies to understand if, and when, these are able to assess or support creative development (see chapters 6 and 9).

Throughout this thesis the descriptions of both creative teaching and formative assessment, as detailed in chapters 2-4, will be duly reflected upon to provide an insight into the nature of the teacher’s creative practice. It is hoped that by examining these practices it will highlight where opportunities to stimulate the child’s curiosity occurred and ultimately, how this can (or did) lead to the reification of creativity-in-learning.

Chapter 5

Methodology

5.1 Introduction to my research approach

This first section of my methodology chapter will explain my position, having been employed as a scientist and teaching assistant (TA), within which I am working, as a researcher. It will also describe my particular standpoint regarding what I want to find out. I will then consider how these former occupations have influenced and shaped my approach to the research project. As a qualified scientist I recognised that I would need to consider carefully how to carry out this study, because it is very different from the positivist paradigm that I adopted as a molecular and structural biologist.

The tension between paradigms brings to mind a moment I experienced within the first week of being a TA (you may recognise this story from the introduction of the literature review) a four year old girl, during free time, in a foundation stage classroom saw a spider sitting in the middle of a web, which was situated in a bush next to a small red berry. The girl knew that the berry could be a source of nutrients and proceeded to tell me that the spider had spun its web next to its required food source. Reflecting upon this perfect example of an alternative conception (Driver *et al*, 1994), it has, since initially experiencing it three years ago, made me reflexively consider epistemologically what it meant. At that time, I was in the process of conceptualising my own understanding of the educational research world (albeit it initially in a positivist way), if I had, at that time been more of an interpretivist researcher, I would have wanted to know 'why' she thought that. Since then I have focused more on the others' subjective understandings of teaching and learning, and this thesis is testament to my learning journey from beginning as a positivist researcher to becoming much more interpretive.

My transition between the paradigms (positivist to interpretivist) is described in greater depth below; first briefly through an explanation of the phases of my research (in section 5.2) and then via a fuller, richer description of becoming more interpretive (section 5.3.1).

5.2 Phases of research design

As I have already stated, whilst developing the study there was an evolutionary development from a positivist stance (for I had been a structural biologist for over a decade) towards a more interpretivist approach. As I traversed between these two paradigms I deliberated upon the various methods of data collection and forms of analysis available to me. My methods evolved as I observed teachers' practices within the primary science classroom. These observations enabled me to begin to appreciate how practitioners interacted with their perceptions of 'what is creativity?' to develop lessons that enabled the children to be creative. For example, when fostering creativity one teacher may choose to demonstrate a 'WOW' experiment for the children to watch (Feasey, 2005), whilst another may allow the children to investigate what would happen during the same experiment through individual discovery learning. I realised that both of these approaches could be labeled as creative pedagogy but one would be much more teacher initiated and the other much more child-led. This kind of pedagogy (which involved using innovative approaches or resources) has become known as creative teaching, from which NACCCE (1999) identified two approaches, they were: 'teaching creatively (TC)' and 'teaching for creativity (T4C)'; both of these pedagogical practices are described in the literature review (Chapter 2). Jeffrey and Craft (2004) suggested that, in a creative classroom, when teachers teach creatively children could also, simultaneously and/or sequentially innovate. However, Craft (2005:43) noted dichotomising the choice between teacher and child initiated activity could be contrary to the development, and cultivation of creativity, within education. After giving the above further consideration I also subsequently recognised how creative teaching involved the interactions (spoken and actional) of both the teacher and their pupils. It is these thoughts and ideas that have informed my thinking to construe my research questions (found in section 5.4) and develop the three stages (briefly outlined below) in my research.

5.2.1 Phase 1

During the first stage of the research I sought to develop an understanding of the characteristics of teaching which supported opportunities to develop creativity in primary science. This was achieved through an in-depth review of literature and supported by three observations in different primary schools. This initial review of literature and scrutiny of practice augmented the creation of an observational tool which provided a visual interpretation of pedagogic features involved in generating creativity in science classrooms (see 5.6.2). During this phase I also began to review the nature of formative assessment strategies and the ways they may support creativity.

5.2.2 Phase 2

The second phase endeavoured to validate the devised observational tool developed in phase 1. It was intended that this analytical framework would highlight the generalisable characteristics of the different teachers' practice, whilst illuminating key aspects of creative teaching (e.g. the types of verbal exchanges taking place, risk-taking and autonomy) which were examined in chapter 2 (2.2-B.1.1.2 – B.1.1.4). It was my intention during this phase to consider how the data from the observations could eventually be cross-referenced with an analytical tool which examined the fostering of creativity through verbal exchanges.

During phase 2 I also intended to develop and pilot a survey and interview questions. These would enable me to explore teachers' perceptions of creativity and their self-reflections about the ways they developed (and assessed) it in their classrooms. It was intended that this information could then be contrasted with the observations (pilot and main phase) to gain insights into the nature and extent of creativity that appeared to be arising in primary science classrooms.

5.2.3 Phase 3

The third and final stage involved testing the reliability of the developing observational framework from phase 1, i.e. how it clarified the features of creative teaching to augment the development of creativity. This was achieved through five further observations of teachers teaching different science lessons. These five observations included the same three teachers who were involved in phase 1 and two others. By attempting to understand the nature of creativity in the science classroom I reflexively realised that the analytical framework and key characteristics of creativity I initially focused upon did not examine the kinds of strategies the teacher employed to foster its development; for this, an examination of the affordances that the teachers provided to render creativity more possible needed to be elucidated. This was achieved through the development of an events map which exemplified what the teacher made present (or visible) to the learner through the activities to develop creativity (see 5.6.2.7). It was not only my intention to create representations of creative practices (through my devised observational framework from phase 1) and an illustrated events map; I intended to cross-reference these with verbal exchanges taking place during the science lesson (see 5.6.2.6). From these three vantage points it was possible to draw attention to the various ways that the teacher provided opportunities for pupils to be creative.

I also went on to consider how formative assessment might be augmented through these social interactions.

This third stage also involved a large scale survey and five complementary interviews (i.e. the teachers' observed). I developed an analytical framework (originally conceived from Ann Oliver's 10 ways to make science creative, see chapter 2.2-B.2.1) to examine the survey responses from section B. A second analytical framework was also devised to examine the nature of the reported formative assessment practices described in section C. This was developed from Wiliam's (2011) five key strategies (see chapter 3.1-D.2). Both of these frameworks were also applied to the interview responses to enable triangulation between observations and survey data-sets.

These three phases are described in detail in the following sub-sections of this methodology (sections 5.3-5.7). To summarise the stages of my research and to outline my focus at these various phases I have created a reference table (adopted from McGregor, 2003), see appendix 5.A. This table highlights the methods applied during these different phases and suggests which research question (section 5.4) they relate to.

5.3 My Methodological approach

For the past decade I have striven to achieve an understanding of both Molecular and Structural Biology. This was a personal endeavour to pursue my own learning of the micro and macro worlds that surround us. Through this area of study, I realised that there was beauty and order within this seemingly chaotic organic world. I wanted, as a scientist to understand at a micro-level how the currency of life, otherwise known as adenosine triphosphate (ATP), was generated. It was this kind of thirst for knowledge (a curiosity) that scientists (people like Al-Alhaytham) have been recognised to exhibit (Schmitt and Lahroodi, 2008). Upon realising I had a desire to understand the origin of creativity-in-learning science I took advice from Denzin and Lincoln (cited by McGregor, 2003) when they stated '…researchers employ…purposive, and not random, sampling methods. They seek out groups, settings and individuals where...the processes being studied are most likely to occur' (*ibid*:97). By considering my prior education I realised, as Alexander (2010) suggested, that '…verbal and social engagement with others is the seed-bed of cognitive development and learning' (*ibid*:90) and that my scientific curiosity arose during the most interactive years of my young life, that is during my primary school education. Thus it is this age group (4-11) that my research focused on.

5.3.1 Becoming more interpretivist

Having been a positivist researcher and suddenly finding myself adopting an interpretive approach to my research there were paradigmatic dilemmas. However, through observing the practice of recognised 'creative and expert teachers' in various primary schools, e.g. teachers who had been recognised by the Primary Science Teaching Trust (PSTT) (the criteria for this acknowledgment can be found in section 5.6.1.5), I came to realise the difference between quantitative and qualitative information that could help me respond to my research queries. Initially I construed models of teaching (as an objective external observer) and not through a more subjective lens of (the teachers or children) who were directly involved. I was, to all intents and purposes, striving to pursue, what Cohen *et al* (2011) called, a normative paradigm (akin to a positivist stance). That is, I was epistemologically looking for human behaviour that could be governed by a set of rules (Edirisingha, 2012). However, I came to appreciate, as Denzin and Lincoln have stated, that:

> 'All research is interpretive; it is guided by the researcher's set of beliefs and feelings about the world and how it should be understood and studied…Each interpretive paradigm makes particular demands on the researcher, including the questions the researcher asks and the interpretations he or she brings to them' (Denzin and Lincoln 1994:22).

So whilst it could be argued that I was methodologically positivist initially in my approach (Edirisingha, 2012) because I was a detached, external observer, I came to realise, as Denzin and Lincoln claim, that over time I became more interpretive, seeking to understand how others felt and understood the world. That is, I became more ethnographic by trying to make sense of the everyday, socially complex world of the primary science classroom from within, that is, through the perspectives of the teacher(s) and their pupils' perspectives (Cohen *et al,* 2011).

Sfard (1998) also informed my transformation in becoming more interpretivist by stating that it was akin to an 'acquisition metaphor' (AM). This metaphor has been referred to before in the literature in section 2.2-A.3.4. She describes this as occurring when:

> 'Concepts are able to be understood as basic units of knowledge that can be accumulated, gradually refined, and combined to form ever richer cognitive structures. This picture is not much different when we talk about the learner as a person who constructs meaning. This approach that today seems natural and self-evident, brings to mind the activity of accumulating material goods.

> The language of “knowledge acquisition” and “concept development” makes us think about the human mind as a container to be filled with certain materials and about the learner as becoming an owner of those materials’ (*ibid*:5).

Here Sfard differentiates between the learner as someone *collecting* or acquiring knowledge and someone learning something through participation in activities with others. A useful metaphor would be to visualise a Wren carefully placing twigs and grass, beginning with the outer layer, to build a nest accruing its form piece-by-piece. Like the Wren, I was accumulating the aspects of knowledge from my observations to form a picture (or model) of teaching and learning that was taking place in creative classrooms. The accumulating knowledge of features of creative practice resulted in my development of diagrammatic models that generalised aspects of creative teaching.

To further augment the ‘interpretive’ aspect of my research, I decided to take a more active role within a primary school. I became a TA which meant I could become more familiar with teaching and learning processes within a school. Pocock relates this to the anthropological process:

> ‘In our dealings with other people we are constantly interacting in terms of shared and differing models and we are often modifying our models, or should be. The only difference between this and the attempt to understand a very different social scene is that in the latter case the process of interaction is slower and much more conscious’ (Pocock, 1998:26-27).

This more anthropological approach meant I could review the pedagogic models I had construed with a metaphorical positivist hat on to re-consider the data in a more interpretivist way. Thus ontologically I could begin to appreciate the viewpoints of the actors (teacher and pupils) involved (Edirisingha, 2012). It was through observing, experiencing and reflecting upon the regular, repeated patterns and constant motion (and at times commotion) of the primary school science classroom that I realised it was the teacher who was the power house (the mitochondria) of the classroom. It was they, and the way they presented and engaged the children with the science curriculum that could potentially energise and invigorate the children to want to know, to participate with science (i.e. the affordances extended to the children through the teacher’s pedagogic creativity so that the children could be enthused to innovate, that is to be creative for themselves).

Sfard (1998) would have described my learning through the participatory role (as a TA within the science classrooms, and through discussions and collaborative workings with my supervisors, which involved me more in a community of educational researchers) not as '...the existence of some permanent entity [e.g 'concept' or 'knowledge' but as being] replaced with the noun "knowing" which indicates action' (*ibid*:6). This she explains is the 'participation metaphor' (PM) (referred to previously in section 2.2-A.3.4). Taking an active role within the primary classroom itself, I realised I had come to appreciate and understand Cohen *et al's* (2011) description of an interpretivist approach.

> 'Interpretive approaches…focus on action. This may be thought of as behaviour-with-meaning; it is intentional behaviour and as such, future orientated. Actions are only meaningful to us in so far as we are able to ascertain the intentions of actors to share their experiences. A large number of our everyday interactions with one another rely on such shared experiences' (*ibid*:17-18).

Cohen's description of the interpretative approach also highlighted the suggestion that the rigid descriptors of my observational framework (which made static the descriptions of how I originally perceived the individual teachers providing opportunities to develop creativity through the science curriculum) were not enough to ascertain the teacher's actual intentions behind their actions. Sfard (1998) illustrates a key difference (cited below) between AM and PM learning, which resonates with the two research paradigms.

> 'The talk about states [in my case the descriptors of the devised observational framework] have been replaced with attention to activities. In the image of learning that emerges from this linguistic turn, the permanence of *having* gives way to flux of *doing*' (*ibid*:6).

According to Sfard there are some that would argue that an ontological shift, such as mine, throughout this research is contradictory and simply would not work.

> '…people may say, the AM and the PM make incompatible ontological claims about the nature of learning. To this, Kahn, Rorty, and many other contemporary philosophers would respond that the metaphors are immensurable rather than incompatible…this means a possibility of their peaceful co-existence' (*ibid*:11).

Sfard counters critics to explain that they were well-suited to explain differing research paradigms:

> 'It seems the most powerful research is one that stands on more than one metaphorical leg (cf Sfard, 1997). An adequate combination of the acquisition and participation metaphors would bring to the fore the advantages of each of them, while keeping their respective drawbacks at bay' (Sfard, 1998:11).

My experience of the contrast between the AM and the PM has enabled me to reflexively recognise how I have changed through participation in my research.

Therefore the study has developed from my own subjective exploration of the ways that children and teachers engaged with and participated with learning, in the primary science classroom. During this personalised anthological approach attention was paid to the ways that teachers perceived creativity and also acted to develop it. That is, the thesis sought to define and critically construe the active ways that learning in primary science classrooms could be creatively nurtured through the teachers' practices. To 'frame' this research four questions were devised to examine the ways in which teachers developed and supported the development of creativity in their primary science classrooms.

5.4 Research questions

The formulation of these research questions (RQ) was through what Jewitt (2012:16) referred to as a *'general method'*. That is, I reflected on my questions as my research progressed and reviewed them as the data became more apparent. The questions are:

1) How do teachers describe and promote creativity in the primary science classroom?
2) What appear (from researcher observations) to be key features or characteristics of teaching to support creativity?
3) Can teachers' descriptions of formative assessment-in-practice elucidate how they (could or already do) provide opportunities to assess creativity-in-learning?
4) How might on-going assessment practices be naturalistically adapted to assess creativity?

Each of these RQs can be found associated to the various research stages and methods described in the tabulated summary of my research in the appendices (see appendix 5.A). Throughout this chapter I will refer to these RQs by number as and when the methods, which help to answer them, arise. However, before detailing the methods employed in this research, I will first describe my methodological approach.

5.5 The methodological approach

It was Scott (1996) who described the methodological approach as '…a distinct way of approaching research with particular understandings of purposes, foci, data, [and] analysis…' (*ibid*:61). This prompted me to realise that, having changed my methodological stance from a positivist focused on quantitative data to an interpretivist, more concerned with qualitative information, I had to re-consider carefully each of the practices I chose to employ, not only when collecting the data but also when subsequently analysing and scrutinising it. I also had to reflect upon the number of 'practice' episodes required, for as Denzin and Lincoln (1994:4) noted, 'It is understood…that each practice makes the world visible in a different way. Hence there is frequently a commitment to using more than one interpretive practice in any study'. Drawing on Denzin and Lincoln, I decided to commit to more than one method of data collection, a study by Johnston (2007) indicates why this was a necessary provision.

Johnston's (2007) research indicated that there was little correlation between 10 pre-service teachers' espoused views of their creative practices and what was, in actuality, observed in the classroom. For example, out of the 10 pre-service primary school teachers, four had described their practice as being child orientated (that is, children constructing their own understanding through exploration and discovery), five claimed to view their lessons as a mixture of teacher-led (imparting knowledge through instruction) and child-led self-discovery, and finally one teacher claimed to follow a highly structured teacher-led practice. After receiving specialist training in primary science and then planning for a, child-led, discovery science lesson, all ten pre-service teachers were observed implementing a teacher-led approach despite claiming the contrary (*ibid*). Hence other means of data gathering (besides observations) were employed to ascertain the teacher's anticipated intentions behind the way they structured their science lessons.

Upon considering the necessity of employing more than one method of data collection I took it upon myself to ask the teachers (through both survey and interviews) to explain their reflective views of their creative practice, and the ways that they thought children could develop personal and collective creativity through them, whilst simultaneously providing examples of when teachers report to employ these to augment the children's creative development (responding to RQ1).

As well as answering this RQ, the survey (and interviews) invited the teachers to describe the range of different strategies they use to currently assess their pupils' on-going progress in science learning and if they are, or have considered, assessing creativity. The responses were examined to find out whether the teachers perceived formative assessment as an instrument to illuminate critico-creative practice (Fisher, 2001), or if it is used, by the teacher, as a tool to simply assess where the pupils were in their learning (Wiliam, 2011; Black, 2012). This helping me to answer RQ3.

Scott also described the methodological approach as '…a distinct way of approaching research with particular understandings of… the relationship between data and what they refer to…' (Scott, 1996:61). As Scott highlights here my methods and my data relate to each other, so research can be triangulated to allow for discrepancies to be pursued. It also meant that, as Mitchell (2006:40) stated, it should '…provide the optimum conditions for the acquisition of those illuminating insights which make formerly opaque connections suddenly pellucid'.

The three methods of data collection adopted and included within this research project were therefore, surveys, observations and interviews. These are examined consecutively in the following section.

5.6 Methods

5.6.1 The survey: garnering teachers' views of creativity in the science classroom

Whilst Brewer (2000) may claim that ethnography should avoid surveys as a means to collect data, Cohen *et al* (2011) reported that this approach could examine multiple viewpoints and subjective understandings through wider social groupings. To achieve this Craft *et al* (2014) employed surveys to explore UK educators' (from primary to higher education) perspectives of creativity through an ethnomethodological approach. Whilst this may seem contrary to Brewer's advice, Craft *et al*'s study was able to draw out common themes, by triangulating the survey data with interviews and observations. This illuminated aspects of creativity the 18 educators involved in the study valued. I, like Cohen *et al,* believe that a survey following an ethnographic dimension could go on to represent a wider population of teachers' perspectives, and that this, through triangulation with other methods of data collection (i.e. observations and interviews) akin to Craft *et al*, would enable me to gather a rich understanding of the ways primary school practitioners perceived, developed and assessed creativity in the science classroom.

It was as a TA that I developed an anthropological perspective of the teachers' viewpoints (Pocock, 1998) about teaching and learning primary science. This helped me to develop pertinent questions that would focus teachers to reflect upon understandings of their own creative practices and the numerous strategies they used to develop and formatively assess creativity. Pocock had previously recognised modifying these questions would be a slow and very conscious process, and this is probably why it took over a year and a half of immersing myself in the primary school culture to develop the final survey (see appendices 5.C). The length of time is also representative of the period required to position myself as an *insider* within my own social investigation (Thomas, 2009), that is, I was no longer be an external detached or invisible participant in my own research (a positivist).

5.6.1.1 Aims of the survey

As I pointed out above, the survey, as a method of data collection, was adopted to gain an insight into the wider population so that multiple teachers' perceived views of creativity in the science classroom could be explored, and it also examined how they may (or may not) formatively assess creativity within a science lesson. A copy of the questionnaire used for the survey can be found in appendix 5.C and details of its development can be found below within the following sections.

5.6.1.2 Formulating the survey

The process of formulating the survey would, according to O'Leary (2010:136), begin with 'concept operationalization' otherwise known as '…the turning [of] abstract concepts into measurable variables' (*ibid*). This construction would be related to the nature of the data I was seeking. Cohen *et al* (2011) advised that this should take place through three phases. First to clarify the general purpose for a '…concrete set of aims' (*ibid*:379). The set of aims in this case was to garner teachers' espoused perspectives of creativity and how creativity is (or can be) formatively assessed in science lessons. Secondly, Cohen *et al* suggested identifying and itemising subsidiary topics related to the survey's central purpose. In my research this would involve considering how teachers describe creativity (and its possible assessment) through a) their creative practice and b) the children's learning. The third phase then involved the formulation of specific details required from the subsidiary topics. That is to formulate the most appropriate kinds of questions to garner the data required to answer the research questions being posed. Thus when structuring a survey Cohen *et al* are reminding us that it is important to plan it in such a way that the data analysis can subsequently proceed in a coherent and planned way. The survey's organisation is described in the following section.

5.6.1.3 Main phase survey structure

The main phase survey (appendix 5.C), in the end, consisted of three sections (A, B and C). Each section in the questionnaire was distinct in its questioning, for example:

5.6.1.3.1 Section A

Section A sought personal details such as: the name of school; name of teacher; the year currently taught; the length of service and year groups previously taught. It was structured, to obtain demographic information from the respondents to the survey, a procedure adapted from Kamphylis's (2010) doctoral thesis.

5.6.1.3.2 Section B

Section B contained questions which were designed to understand the teacher's perceptions of creative teaching techniques and how they were employed to support creativity. This section steered me towards answering RQ1.

The first sub-set of questions (1-7) was designed to tease out, from the teacher, their self-reported views of the ways they supported the development of creativity. A simple 3 point Likert-type scale, i.e. frequently (F), sometimes (S), and never (N) offered limited choices that could be rapidly responded to. It also provided a method by which data could be swiftly analysed to indicate the relative frequency of a range of teachers' perspectives regarding their practice. The use of a three-point Likert scale was originally devised by Lehmann and Hulbert (1972). Kamphylis (2010) also employed Likert-type scales when surveying his selected teachers, however he adopted a five-point scale, but others have, like myself, opted for three-points (Robinson *et al,* 1999, cited by Krosnick *et al,* 2005)

Five of the sub-set questions were originally construed from the Primary Science Quality Mark (PSQM) C1 gold award criteria. The PSQM scheme is described in further in section 5.6.1.5. The C1 criteria invites the teacher to consider whether '[a]ll pupils are actively engaged in a science enquiry; using a variety of enquiry strategies, independently making decisions, using evidence to answer their own questions, solving real problems, [and] evaluating their work'. This PSQM (2015) description was chosen as a backdrop for the five closed questions because it resonated with my description of children's curiosity, whereby the pupils actively partake in the activity (see literature review, section 2.2-A.3.4). This, I believe, is a fundamental consideration when deliberating upon developing creativity. Thus, it informed the focus of five of these closed questions (see questions 1, 2, 4, 5 and 6, appendix 5.C).

Attention was also paid to the CLSP definition of creativity when generating these Likert-scale questions. The CLSP stated that creativity can be evidenced when children '…generate and evaluate ideas and strategies…' (Stylianidou et al, 2014:2) either '…as an individual or community, and reason critically between these' (Glauert and Manches, 2013:59-60). After deliberating upon the notion that the iterative process of evaluating and generating ideas was an integral part of creativity in education (see literature review chapter 2.2-A.2) it would have been remiss of me to neglect it within this list of characteristics (see questions 3 and 4, appendix 5.C). Finally Runco's (2003) construction of new meaning also informed the generation of these questions, because expressions of creativity (outlined in chapter 2, section 2.2-A.2) also requires the teacher to appreciate and augment the child's own personalised, freshly transformed ideas as part of their learning (see question 7, appendix 5.C). Together these three sources (PSQM, 2015, the CLSP's definition of creativity and Runco, 2003) informed the creation of the first sub-set of seven questions (i.e. they incorporated curiosity, asking questions, coming up with ideas, reflecting upon ideas, thinking independently, overcoming challenges and creating something new). Choosing these characteristics to be part of this initial sub-set of questions was also supported by Ann Oliver's descriptions of ten ways to engage a learner and make science creative (see literature review 2.2-B.2.1). For example, in just one of the ten categories 'turning predictable outcomes into something better' Oliver listed 13 creative approaches (these were previously highlighted in section 2.2-B.2.1.1). These 13 practices reverberated through the seven features mentioned above (Oliver, 2006:26).

However, I feel I need to highlight how a closed set of questions, which contain these seven features would not satisfy, or illuminate, the multifaceted nature of being creative (Lipman, 2003). To this end I planned to elucidate richer, more reflective responses from questions that enabled readers to appreciate what teachers' pay attention to, when they fostered their own and their pupils' creativity. These questions were open-ended, exploratory questions to enable the teachers to write freely (Cohen *et al,* 2011). This strategy of using Likert-style tick boxes followed by open-ended questions was also akin to Kampylis's (2010) research project.

With teaching and learning in mind, questions 8 and 11 (cited below) were specifically designed to garner the teachers' perspective of their creative pedagogical practices in the science classroom. Whilst questions 9 and 10 (also cited below) examined how the teachers perceived these as having a direct effect on the opportunities to develop the subjective creativity of their pupils.

8) Please describe the most creative science activity you have taught;
9) Please describe the most creative thing your children (or child) has done in a science lesson;
10) Please describe the most creative thing you think your children (or a child) have/has done in any lesson, not science! and
11) Which aspects of your creative lessons has sparked the children's interest in science?

I also invited the teachers to respond to two further open-ended questions in an attempt to discover more about the issues and problems of integrating creativity within the science lesson. The two questions were: '*What things make being creative in the science classroom difficult?' and 'Why do [they, the teacher] think children might find it difficult to be creative in a science lesson?'* (See appendix 5.C for the complete survey). These two questions (12 and 13 respectively) were later triangulated with questions asked during the interviews (see appendix 5.K).

Section B was followed with section C, which was specifically designed to explore how (or if) the teachers formatively assessed creativity during science lessons.

5.6.1.3.3 Section C

In section C, the teachers were initially asked to consider *which aspects of students' thinking are not measured via summative science assessment tests?* (Question 14). Following this, I also invited the teachers to think about how they perceived and described the way they formatively assessed learning and how this related to assessing the children's creative thinking (questions 15-17). These three questions (15-17) enabled me to answer RQ3 and can be found below.

Q15) Can you describe the range of different strategies you use currently to assess your children's on-going progress in science learning (i.e. tests, tasks or assessment strategies)?

Q16) Which of the assessment strategies described in Q15 most closely assess creative ability in science? and
Q17) Why does the assessment strategy discussed in Q16, in your opinion, more readily assess creative ability?

At the end of the survey the respondent was invited to opt into a follow up observation or interview by simply ticking a yes or no box, after which they were then thanked for their time and asked to forward the survey back to the University.

5.6.1.4 Piloting the survey

Prior to the main phase survey being disseminated in April 2015, a pilot survey was distributed in October 2014 (appendix 5.D). During this stage of my study 40 teachers involved in the Thinking, Doing and Talking Science Project (TDTSP), which was funded by the Educational Endowment Trust (EEF), were invited to complete the pilot survey.

The TDTSP was described by the EEF (2016) as a programme that '…sought to support teachers to be more creative and thoughtful in planning their science lessons'. This, they claimed, could be achieved by training teachers in strategies which would encouraged the higher order thinking skills of their pupils.

The TDTSP sought to assess the impact of its professional development programme on attainment level outcomes of year 5 students through a randomised controlled trail which took two years to complete. During the first year, two teachers from each of the 21 participating schools received five days of professional development training (delivered by Science Oxford and Oxford Brookes University). A second group of 20 schools did not receive this training. Instead they formed a control group for comparative purposes and then received the same training in the following year. It was this second group of 40 teachers who were invited to complete the first pilot survey during a continuing professional development (CPD) training day. Eleven surveys were returned (a response rate of 28%). The demographics of these eleven participants are represented in table 5.1 below and were collected from section A of the survey. This method of collecting the demographics proved successful, and unambiguous, thus it remained the same in the main phase survey.

N=11		Total number
Gender	Female	9
	Male	0
	Unspecified	3
Years of experience	1-5	6
	6-10	2
	11-15	1
	16-20	0
	21-25	1
	26-30	0
	31-35	1

Table 5. 1: Demographics of first pilot survey participants

Post initial piloting, a further 11 schools from the TDTSP were purposively selected from the 21 schools involved in the first year's training, (see appendix 5.E). Teachers from these 11 primary schools were invited to complete a reconceptualised second pilot survey in April 2015, just prior to main phase data collection. There were four selection criteria involved in this part of the process. They were:

- Schools involved in the professional development training in first year of the Thinking, Doing and Talking Science project (TDTSP);
- Had a 90% attainment at level 4 sciences or above, at the end of key stage 2 in the previous academic year;
- Were designated, by Ofsted, as an outstanding or good school and
- Creative teaching was evident in their most recent Ofsted reports.

It was felt, by adopting the above criteria, it would ensure that these schools were more likely to display creativity in their science lessons. Of the eleven teachers who were invited to complete the second pilot survey, three questionnaires were returned. This is a response rate of 27%, similar to the first pilot. The demographics of these three participants are represented in table 5.2 below.

N=3		Total number
Gender	Female	2
	Male	1
	Unspecified	0
Years of experience	1-5	0
	6-10	0
	11-15	2
	16-20	0
	21-25	0
	26-30	1
	31-35	0

Table 5. 2: Demographics of second pilot survey participants

The piloting of the survey was paramount to its success, as it highlighted items for removal or reconsideration (Cohen *et al,* 2011). An example of a question that needed this type of revision was, *'How often do you use any of the creative teaching techniques/strategies listed below in science?'* (question 1 from the first pilot survey, appendix 5.D). A table was designed and contained various creative approaches/strategies, these included: observations, openly sharing ideas and aesthetic experiences – these were synthesised from the conceptual framework from the CLSP (Glauert and Manches, 2013; Cremin *et al*, 2013). The table also incorporated a three point Likert rating scale (i.e. F, S or N) which requested the teacher to indicate how often they felt they adopted these creative practices; they were also invited to expand upon these approaches, if they wished so to do. Upon collecting the data from this pilot stage, every teacher had indicated how often (F, S or N) they believed that they adopted each of the techniques/strategies, but it was discovered that the further detail requested was too cumbersome (only three of the eleven teachers provided it). I was informed, by the teachers, that the table contained *'far too much information to complete'* and was somewhat *'off-putting'*. Thus this table needed to be reconsidered to optimise the quality of further responses. The table was reconceptualised (see appendix 5.F) to elicit how frequently the teacher believed they supported the development of creativity through several criteria (as outlined in more depth in section 5.6.1.3.1 of this methodology chapter). The teachers were also invited to list the different ways (activities and strategies) that would support the children when developing these features. During the second pilot the three surveys that were returned all indicated, through the Likert scales, how frequently they supported the children to develop key features of scientific inquiry, but only one provided examples of the different ways they augmented these features. With the lack of fuller descriptions, the table became a sub-set of questions (1-7), designed to simply elicit how frequently the teacher believed they supported the development of creativity (see appendices 5.C). Further reflection of all the questions, in sections B and C, underwent similar contemplation and adjustment if and when required.

5.6.1.5 Inviting teachers to participate in the survey

The main phase survey was distributed, on-line, between April and July 2015. The two groups of participants invited to complete the survey are described below.
The first group of participants to receive the survey were 150 college fellows from the PSTT. This is a college initially set up in 2010 to bring together the winners of the PSTT Science Teacher Award (PSTT, 2013). The award first began in 2002 with just two teachers receiving

primary science teacher awards (PSTA) but since 2012 the PSTT have awarded approximately 25 primary school science teachers a PSTA every year. To win this award the PSTT invite colleagues or peers to nominate an 'outstanding' teacher. These teachers are described by the PSTT as being:

- 'innovative and creative in teaching science;
- [they] inspire colleagues and contribute to developing science in their school and beyond;
- [and finally they] engage pupils in the excitement and fascination of science'

(PSTT, 2016a).

Following this nomination, the 'outstanding' teachers are shortlisted and then visited by PSTT panel members. During this visit they are observed teaching a science lesson and subsequently interviewed. The teachers that go on to win the PSTA are described as being innovative and energetic in the classroom, with their impact being felt not just by the pupils, but by the parents and fellow teachers (*ibid*). Further information about the PSTT College can be found through their website (PSTT 2016b).

Out of 150 potential PSTT college fellows invited to complete the survey 13 returned it completed. Whilst the response rate was well below the pilot, at 8.7%, which can suggest a potential compromise in the reliability of the data (Cohen *et al,* 2011), Witmer *et al* (1999) had previously noted that on-line surveys tended to have low return rate anyway (*ibid*). That is, my presence when distributing the original pilot surveys at the TDTSP training day could have ensured a greater response rate. Pooch (2003), cited in Cohen *et al,* advised increasing the sample size to decrease the number of non-responses. Upon considering this advice I decided it would be wise to also invite those schools who had been bestowed a PSQM award to complete my survey. The rationale behind this decision being that the PSTT also encourages all of its college fellows to work towards a PSQM award, for both claim to '…share a close synergy in [their]…aims and objectives' (PSTT, 2016b).

The PSQM award scheme was, according to Turner *et al* (2011) set up so the science subject leaders, in their respective primary schools, could self-evaluate the quality of their science teaching and learning, and identify areas where there was room for development. This was (and is) achieved against the backdrop of 13 criteria. One of these includes the C1 criterion which was adapted to inform five out of the seven Likert-scale questions found in the survey. Each school can then aim for either a bronze, silver, or gold award by:

- 'audit[ing] existing provision in science;
- creat[ing] and implement[ing] an action plan to develop all aspects of science teaching and learning [and]
- completing a reflective submission [a portfolio] with key pieces of evidence to demonstrate the impact of their leadership.'

(PSQM, 2015)

Throughout this process the schools are supported by other PSQM hub leaders and members of the PSQM team, through compulsory CPD modules and expert mentoring. This network of people was reportedly set up to address what the schools and science leaders needed to achieve the award. Considering the nature of the PSQM award scheme and its synergies with the PSTT it seemed logical to invite all 877 schools, who had achieved the PSQM award by 2016, to complete the survey. Supplementary information regarding the PSQM award scheme can also be found on their website (PSQM, 2015).

This time I received 88 completed surveys; however, the response rate was again 10%, akin to the first wave of responses. This only reinforcing Witmer *et al's* (1999) concern that on-line surveys tended to have a low rate of return (*ibid*). It was also noted that 12 out of 13 PSTT college fellows, who answered the first wave of surveys, were also teachers at schools taking part in the PSQM scheme. This may be why I received no further response from teachers in these establishments. Upon reflection if I had administered the surveys personally (face-to-face), just as Franklin (2016:48) had, during the 2015 PSTT annual conference, in Birmingham, this could have generated a similar response rate (i.e. 64%). Nevertheless by the end of July 2015 101 surveys were completed and submitted.

Whilst some may claim that the final return rate may have compromised reliability (Cohen *et al,* 2011) the teachers invited to complete the survey were considered, by the PSTT and PSQM scheme, to be innovative in the way they practiced (and evaluated) science in their respective schools. Thus I was endeavouring to illuminate self-reported exemplary (creative) teaching practices and not evaluate quantifiable measures of creativity.

<u>5.6.1.6 Analysing the teachers' responses</u>

All 101 submitted questionnaires were entered onto Nvivo software ready for coding. This software proved to be a powerful tool from which to edit, code and analyse the numerous multifaceted self-reported episodes of the teachers' pedagogical practices. It can also organise large volumes of qualitative data into classification systems (or categories). To help explain how the responses to the questions were examined, the following sections below will describe how each of the surveys sections (A, B and C) were analysed. The results of this analysis can be found in chapter 6.

5.6.1.6.1 Section A: demographics

Table 5.3 summarises the analytical demographic of the participants, that is the results of section A of the survey. It indicates that the majority of the participants who responded to the survey were female (83%). This is consistent with the reported percentage of female teachers in primary education in the United Kingdom (87%), as reported by UNESCO Institute for Statistics (The World Bank, 2013).

N=101		Total number
Gender	Female	79
	Male	15
	Unspecified	7
Years of experience	1-5	29
	6-10	21
	11-15	15
	16-20	18
	21-25	6
	26-30	6
	31-35	2
	Unspecified	4

Table 5. 3: Demographics of main survey participants

5.6.1.6.2 Section B: creative practices and learning

As I have previously stated Section B invited teachers to describe how they nurtured creativity through their practices; in the following sections I explain how I examined the descriptive responses received.

5.6.1.6.2.1 Questions 1-7

As advised by Lehmann and Hulbert (1972) the results of my 3-point Likert-style like questions were used to average the percentage frequency of teachers who believed they supported creativity through the seven features previously outlined in section 5.6.1.3.2. This, it was intended, should provide an indication of how the teachers believed (or perceived) they were developing creativity. Whilst this provided me with an insight into how frequently the teachers believed they supported specific aspects of creativity it did not illuminate their actions and intentions when developing and augmenting the pupils' creativity. It was my intention for question 8-11 to elucidate the rich, reflective responses required to garner this level of detail. These four exploratory questions have already been detailed in section 5.6.1.3.2.

5.6.1.6.2.2 Questions 8-11

The teachers' responses from these four questions (8-11) were examined with my interpretation of Oliver's ten ways to be creative in science, in mind (as defined in the literature review see 2.2-B.2.1). An example of the connective nature between Ann Oliver's ten categories can be seen through examining response 1 from question 8. The response number relates to the order in which the completed surveys were returned, thus this was the first survey returned completed.

> Response 1: 'when I am approached with things like "I know how to be healthy and take care of my teeth," we physically look at our teeth with disclosing tablets and brush our teeth'.

Through response 1 I have inductively reasoned that by inviting the children to stain their teeth (with disclosing tablets), the teacher would have *made the ordinary [the children's teeth] fascinating,* (for the young pupils would have seen and would be very familiar with their own teeth through their daily cleaning routines); this different way of visualising plaque would have enabled the children to observe its build-up in bright and vibrant colours. The activity, therefore, could provide the children with an illustrated opportunity to connect this observation with the proliferation of bacteria (modelling explanations). Thus the activity not only *made the ordinary [their teeth] fascinating* but also represented my interpretations of *modelling explanations* through *seeing things [their teeth] differently.* In this instance, more than one of Oliver's ten ways could be applied to categorise the creative practice described (or employed) by the teacher. All data gathered from question 8-11, through the survey, has been coded in a similar fashion.

As discussed previously, it was my intention to consider the extent to which the teacher *taught creatively* and how far they enabled the children to develop their own personal creativity by T4C. Thus I realised that the written descriptions of creativity could be categorised as initiated by both teacher and child. Following this realisation all responses from the collected data (questions 8-11) were examined individually in a two-pronged manner. That is, they were scrutinised a second time into sub-coded bilateral categories, 'teacher-initiated creativity' (TIC) and/or 'child-initiated creativity' (CIC), to reflect the possible teaching approach being reportedly adopted by the teacher. This part of the analytical process was akin to how Starcke (2006) examined the written word in classical English literature. Here, like Starcke, I considered the use of the fixed term expressions within the teachers' responses, that is, they could indicate whether the teacher or child-initiated the reported creative episode. For example if the response stated 'I asked…', 'I demonstrated…' or 'the children were supplied with…' then this would be classified as TIC. If it began 'the child(ren) inquired about…' or 'the child(ren) made…' this would be classified as a CIC experience. When the response lacked clarity regarding who initiated it, the activities were sub-coded as a 'creative classroom activity' (CCA). To be coded as a CCA a creative strategy may have been described without indicating who was leading it, or the word 'we' was utilised instead of 'I' or 'the child'. The total number of themes and sub-coded categories per question were tabulated and converted into percentage frequencies. This, it was hoped, would highlighted who (i.e. the teacher or the learner) was more likely to be perceived as being the agentive originator of creativity.

Question 10, unlike questions 8, 9 and 11, sought to explore where and when teachers thought their pupils were creative in other discipline, i.e. when not in science. Whilst I still examined the teachers' responses to this question by employing the framework adapted from Ann Oliver's categorises (as described above), the individual disciplines highlighted as creative by the teachers were also summarised through a frequency histogram, and then briefly reflected upon.

5.6.1.6.2.3 Questions 12-13

In addition to examining the responses to question 8-11 I also sought to understand the challenges that a teacher may face, and the similar issues they perceive a child may have, when trying to be creative during a science lesson. Questions 12 and 13 were designed to elucidate this information respectively (they are originally detailed in section 5.6.1.3.2). The teachers' responses to these lines of enquiry were analysed individually and categorised by means of a grounded approach, which is describe by Peräkylä (2005) as, a search for distinct descriptions where themes are inductively generated from the written accounts themselves. Strauss and Cohen (1998) cited in Patton (2015) described grounded theory in three steps. I adopted these three steps by first examining the basic written descriptions of creative difficulties in teaching and learning, then organising them into discrete categories using the written accounts as a means to elucidate themes. Cohen and Strauss called this conceptual ordering. Finally the relationships between these groups are intuitively considered and an explanatory scheme devised (something Cohen and Strauss named theorising). Brewer explains grounded theory in more simple terms:

> ‘Data is grouped into codes, which represent the categories that appear in the findings. The properties of the codes are identified, leading to further refinement and revision of the codes to account for variations in the properties that have been identified. Data must be examined for new or different properties that require reformulation of the codes or new codes altogether. This is done by the general method of constant comparative analysis…in which codes are constantly compared to instances of data in increasing forms of elaboration and refinement. In this way, categories emerge from the data that constitute exploratory propositions to account for the patterns and regularities represented by the categories’ (Bewer, 2000:152).

This inductive analysis saw underlying patterns of themes emerge from the data. Once the themes had emerged from within the data these were tallied and converted into individual frequency histograms.

Having examined the teachers’ views of their and their pupils’ expressions of creativity I turned to how they (do/could) formatively assess innovation in their science lessons through the assessment strategies they choose to employ (see question 15-17 section 5.6.1.3.3).

<u>5.6.1.6.3 Section C: assessment strategies</u>

However, before explaining how I examined the way in which the teachers reported they assessed learning and/or creativity in science I first asked them to think about what formal summative testing may not measure. This was achieved by inviting them to respond to question 14, as originally detailed in section 5.6.1.3.3.

5.6.1.6.3.1 Question 14

The analytical approach undertaken, to examine the responses from question 14, was akin to that taken for the responses to questions 12 and 13. That is, themes were inductively generated from the written responses. The categories were then tallied and converted into a frequency histogram.

5.6.1.6.3.2 Questions 15-17

Questions 15 through to 17 focused on how teachers currently assessed children's learning and how they believe these strategies could be (or are) adapted to capture creativity. The responses from question 15 were examined with Wiliam's (2011:46) five key strategies of formative assessment in mind. These are:

1. 'Clarifying, sharing and understanding learning intentions and criteria for success
2. Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning.
3. Providing feedback that moves learning forward.
4. Activating learners as instructional resources for one another.
5. Activating learners as the owners of their own learning.'

(*ibid*)

Whilst these five strategies were originally set out and described in the literature review (see chapter 3.1-D.2) the data itself was examined for specific instances of each strategy. For example, when *clarifying, sharing and understanding learning intentions and criteria for success* I was looking for unambiguous reports of when the teacher referred to a learning objective or success criteria. When considering *engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning* I was seeking descriptions of assessment practices that could elucidate the child's learning. To recognise *feedback that moved learning forward* in the teachers' response they would need to clearly describe a strategy which enabled the learning to advance. Finally for the fourth and fifth strategies I looked for descriptions of when the teacher reported the children worked collaboratively or independently, in that respective order. The results of this analysis were tallied and converted into frequency histograms.

After the responses from question 15 were examined they were analysed a second time to ascertain what actual formative assessment strategies were currently being employed to assess learning. That is, the written accounts were re-examined for distinct descriptions of assessment strategies adopted by the teacher (Peräkylä, 2005). These were tallied and converted into a separate histogram. The teachers were than invited to decide which of the formative assessment strategies, they described in question 15, was most likely to assess creativity (see question 16). Their responses were tallied, and also converted into histograms.

However, I subsequently recognised that questions 15 and 16 did not specifically request the full rich descriptions required to conclude whether they had been successful in fulfilling a formative purpose (as was described in section 3.1-C.3). It was only question 17 that asked for an explanation as to why the teacher believed the strategy mentioned in question 16 was able to assess creativity. Thus the written responses from question 17 were examined to find out if the reported assessment techniques were viewed by the teacher as useful strategies from which to formatively support creativity for the child (i.e. they were teacher-focused), or if they saw it as a means for the child to assess themselves (child-focused). This will not necessarily mean that the teacher is activating the child as an autonomous learner, as Wiliam (2011:145-159) described in his fifth strategy, just that the teacher described the child as applying the assessment method themselves (i.e. the teacher stated *'the children are allowed to…'* or *'children often take…'*). The responses from question 17 were categorised into three themes, i.e. as a formative assessment strategy (FAS) when it was not explicit who initiated the strategy, or as either a teacher-focused and/or a child-focused strategy. The results were illustrated in a table format.

Having collected and examined the data from the above survey (for sections A-C) it was noted that whilst the teachers' responses were diverse and descriptive, which enabled me to answer RQs 1 and 3, which in itself met Cohen *et al's* (2011) suggested aims of a survey, they were not rich enough to conclude whether they had, in actuality, illustrated and illuminated distinctive attributes of teaching that supported the development of creativity (here I am referencing RQ2). Neither had it revealed if the formative assessment strategies described had successfully reified creativity-in-learning (RQ4 was left unanswered). It is intended that the observations (described in the following section) could illustrate and illuminate what creative practice looked like, thereby responding to RQ2. The examination of these actual science lessons may also suggest how the AfL strategies employed could be adapted to assess creativity, helping to answer RQ4.

5.6.2 Observing primary school teachers during science lessons

<u>5.6.2.1 Aims of observing creative practice</u>

Having explored teacher perceptions of creativity and the formative strategies teachers used to develop and capture creative thinking through an ethnographic dimension, I also wanted to uncover and illustrate the observable key features of teaching that supports creativity during a science lesson. That is, I wanted to construe what the characteristics of a creative teaching approach were. This was elucidated by reflexively considering eight observed science lessons (Alvesson and Skoldberg, 2009). All eight observations occurred between

December 2013 and November 2015. However, within this thesis only three cases (A-C), from the eight, were selected. This occurred for two reasons: first, all three teachers had been recognised as 'creative and expert teachers' by either their respective primary schools (case A) or by having been recognised and acknowledged by the PSTT to be outstanding primary science teachers (cases B and C). The process of achieving this accolade is described in further depth in section 5.6.1.5. Secondly, and most importantly, these three cases were also chosen because they aptly reflected/illustrated the creative practices described within the teaching continuum, i.e. expositional teaching, TC and T4C (see literature review 2.2-B.3.1). These three cases would go on to form a series of related cases, what this means, in relation to my research (i.e. illustrating features of creative science teaching), is outlined in further depth in the next few sections.

<u>5.6.2.2 A series of related cases</u>

Before clarifying how the three observations (A-C) form a series of related cases, I feel it is necessary to understand what a singular case is. Denzin and Lincoln (1994) claim that 'a case, [that is, either case A, B or C] may be simple or complex. It may be a child or a classroom of children or an event, a happening, such as a mobilisation of professionals to study a childhood condition. It is one among others. In any given study, we will concentrate on the one' (ibid:444). In this study the focused object of interest, the relevant variable as Eckstein (2002) in Van Wynsberghe and Khan (2007) would have me describe it, was the teacher and their creative practice. Thus the three teachers together and the way they enacted their practices in a science lesson (i.e. cases A-C) became the series of cases within my exploratory study. It is through these related cases I wanted to illustrate what features of creative practice looked like. Mitchell highlighted a problem with trying to generalise cases in this manner, that is, the typicality of a case 'from a single instance of an event [e.g. from one science lesson taught by one teacher] may be – and probably is – unique' (Mitchell, 2006:25). However Gluckman (1961), as described by Mitchell (2006), countered this by arguing that social morphology across cases could exemplify generalisable, but distinctive, features of the teacher's practice. Denzin and Lincoln (1994) also argued that if I recognised it as a 'bounded system' features of creative practices could be illuminated.

> 'If we are moved to study it [the teacher and the illustrative features of their practices], the case is almost certainly going to be a functioning body. The case is a "bounded system" (Flood, as reported in Fals Borda, 1998)….It is common to recognise that certain features are within the system, within the

> boundaries of the case, and other features outside…Wiliam Goode and Paul Hatt (1952) observed that it is not always easy for a case researcher to say where the child ends [or in this case the primary teacher practices within a science lesson] and where the environment begins. But boundedness and activity patterns nevertheless are useful concepts for specifying the case (Stake, 1988)' (*ibid*:444).

The bounded system was originally described by Adelman, (1976:49) and by conceiving of my cases to be within such a system, as Denzin and Lincoln have described, it should be possible to characterise features of the teachers' creative practice and to perceive how these are related to nurturing creativity within science lessons.

The illumination of the bounded feature, was a slow, conscientious process, which contained, what Alesson and Skolberg (2009:91) referred to as, 'a thinking where the plurality of interpretations and understanding may collide and bring inspiration'. My thoughts and ideas surrounding the eight observations did, in actuality, coalesce and this brought forth the stimulus to create an observational research tool. This, Alvesson and Skoldberg stated, was a hermeneutic approach, through which a 'meaning of a part [i.e. the bounded system, the case] can only be understood if it is related to the whole [not just the teachers creative practices]' (*ibid*:92). That is, the features of the teacher practices were clarified as I progressed through my reflexive anthropological journey, as described in section 5.3.1.

<u>5.6.2.3 Examining the teachers questions</u>

The beginnings of my anthropological journey, to formulate my observational framework, can be traced back to fully transcribing and analysing the first primary school science lesson I audio recorded. The teacher (case A) was invited to be part of my study for a number of reasons. The school, where she taught, had: - in the previous academic year achieved a 100% attainment at level 4 in science, at the end of key stage 2; their Ofsted rating was 'outstanding', and it was also highlighted, by Ofsted, that the school fostered creativity through arts and music, and planned exciting and purposeful activities throughout the curriculum to promote a love of learning. It appeared likely, therefore, that they would be creative in their science lessons.
Case A provided what was described to me as an end of topic, fully interactive story-telling lesson. This session had been delivered to the same year group (year 2) every December for the past eight years and was highly praised by many of the teachers who had observed it. The lesson lasted for just over 92 minutes and consisted of the teacher

handling and demonstrating objects whilst telling the children the story of 'the history of light'.

After transcribing the lesson (from beginning to end) I chose to initially focus on the questions asked, for the nature of questions asked could have been indicative of TC or T4C. I examined, categorised and counted all the questions asked, akin to an approach adopted by Erdogan and Campbell (2008). My analysis however, was completed using a revised version of Wragg and Brown's (2001) and Brown and Edmondson's (1984) taxonomy of questions (see appendix 5.G). Whilst questions had originally been classified as 'any statement intended to evoke a verbal response' (*ibid*:99), I decided to also analyse the rhetorical ones because the children may still interact on an intrapersonal level with the teacher's vocalised thoughts. It was only through this process of analysis that I began to recognise and appreciate how the teacher could, through their interactions, allow the children to articulate their varying scientific views and ideas.

Other studies examining the use of questions in the classroom have concluded that teachers, in the main, asked closed-ended questions (Wood, 1992; Dillon, 1994), such as, the teacher looking for a brief and/or specific answer (Wragg and Brown, 2001). Examples from teacher A include: *'What happens to clay, when you put it in a fire?*' and *'What happens to metal when it goes into the fire?'*. This pre-dominance of closed questions appeared to be consistent with this first observation (i.e. of the 129 questions asked during the science lesson, 82 were classified as closed questions).

As discussed in the literature review (section 2.2-B.1.1.2), this type of exchange would be of a limited nature and only require the child to recall information when prompted to do so. Dillon (1994) went on to postulate that discussion was better able to open up classroom discourse because, as Hardman (2008:135) stated '…discussion usually begins with a problem in which all the participants share some perplexity…'. However, in the literature review, I conceptualised discussion as uncritical in its nature, perhaps this happens because, as Hardman states

> '…teachers are rarely perplexed about the question they ask, as they typically know the answers, so there is little opportunity for sharing the question and therefore stimulating either teacher or student' (*ibid*: 135-136).

Below is an example from case A of just such a question and answer session relating to an unusual Christmas candle (see figure 5.1).

Figure 5. 1: An unusual Christmas candle demonstrated during case A

Teacher	Christmas, Christmas is coming and there's a little Jesus there and there are the wise men, there's the shepherds, there's Mary and Joseph and it's for celebrating Christmas and I celebrate Christmas with having some candles. Look what happens when I light my candles, light that one, light that one, (.) light number three. Watch carefully and see what happens here. Number Four, number five, (.) number six, (.) oh, give it a minute (.) let's see what's going to happen here. Let's give it a helping hand [holds another flame below the rotor blades] (… done something),(.) it's stuck I think. (.) Right. What's happening? (.)
Child	It's going round.
Teacher	It's going round, isn't it? It's going round, why? You tell me what's happening. What do you think happening then?
Child	Is it the people walking?
Teacher	No, because they're just staying still, they're going round; it's really there….top that's going round. (.) What do think is happening?
Child	Um.. The thing at the top [the blades/paddles of the rotor] is making it go round.
Teacher	Well the thing at the top is going round and that's making all these things go round [points to candles], but why, why is that happening?
Child	Is it because all of the air off the candles makes the top spin and ( ) [the teacher talks over the top of the child].
Teacher	The air off the candles makes it go round, he's right, but why does the air off the candles make it go round? What do think is going up there? If I come here what would I feel? (.) [places hand just below the rotor] Oh.(.) What would I feel? Yes, at the back.
Child	Heat

Case A: Excerpt 5.1

In excerpt 5.1 the teacher appeared to welcome alternative perspectives, but she was uncritical of them, such as her response to the child who thought that the wooden models were actually walking and somehow turning the platform (line 807). After hearing this answer the teacher was directive, made evident by the way in which she proceeded to guide the pupils to recite the answer she wanted to hear i.e. '*all of the air off the candles makes the top spin'* (line 814). This correct answer was achieved by the teacher not addressing the alternative perspective and then guiding the children's attention towards the paddles (line 808-809); she then invited them to think about why *'the thing at the top'* was moving (line 812-813).

As a possible contrast to the teacher's approach Hardman suggested opening up classroom talk and goes on to advocate provocative, open-ended statements rather than questions, perhaps through an explorative conversation (Littleton and Mercer, 2013), which according to Wegerif (2007) would hold different perspectives in, what he called a torque mass. It was Wegerif's (2007) belief that, transformational change (the development of new conceptual understanding) could occur through this mass.

Having now acknowledged that analysing the actual questions asked during a lesson does not recognise the nature of all interactions in the science classroom, each lesson subsequently observed was still fully transcribed and subjected to the same systemic, rigorous process as outlined above. I subsequently chose to graphically illustrate each teacher's question per minute graphically in a frequency timeline (i.e. the questions, per minute, are represented as vertical strings of dots). Case A's question frequency, per minute, is represented in figure 5.2 below.

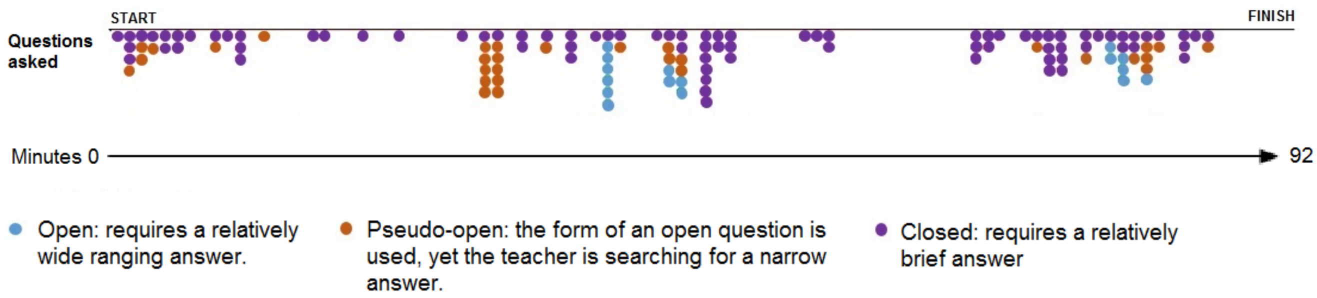


Figure 5. 2: Case A's question frequency per minute

Whilst I have recognised that questioning does not cater for all types of verbal exchanges in the classroom, it was acknowledged that the teacher could monitor factual knowing and/or recall of subject matter through the way they posed questions. Questions, I suggest, can be used in three ways: first Alexander (2008) suggests task specific recitation; then Wegerif (2007) proposes checking for understanding and finally Fisher (2001) advocates questioning to explore different or new perspectives. These became the first criteria of three in a structured framework developed to examine the generalisable features of an individual teachers practice. I propose that this schema highlights the opportunities the teacher provides to develop creativity through the science curriculum (i.e. through expositional teaching, TC and T4C). This is outlined further in the following section (5.6.2.4). The schema was originally developed to inductively formulate my proposition about questioning, and develop a framework to interrogate data to be able to respond to RQ2.

However, as I stated earlier (section 5.6.2.2) the formation of the observational framework was hermeneutic (Alvesson and Skoldberg, 2009). That is, it was only after I invited further creative, expert teachers, to be observed that I started to identify features of teacher creativity. I inductively and repeatedly examined, in increasing depth the transcripts and videos of all eight science lessons observed. Through this process, in combination with my developing literature review, I accumulated the knowledge to form a clearer picture of some of the characteristics of creative teaching. The actual formulation of the observational framework, from its beginnings, is described in the following section.

5.6.2.4 Conceptualising a teaching practice schema

The schema (table 5.4) was initially conceptualised from a modified layout of the Flanders' Interaction Analysis Categories (FIAC) (Flanders, 1970), as tempered by Newman (2004). This FIAC system had 10 categories of communication and has been adopted by various other studies (Wragg, 1999; Thomas, 2009). Whilst O'Leary (2014) claimed that the categories used in a FIAC system could be considered rather generic and would not fully encapsulate the complexities of classroom interaction, he also went on to say, '…in theory, there is nothing to prevent it from being updated to make it more relevant to today's classroom' (*ibid*:50). Within previous studies this systematic system examined and tallied observations and/or instances that took place within a specific length of time, e.g. a ten minute period, (Wragg, 1999; Thomas, 2009). Whilst Wragg and Thomas adopted this 'time sampling' technique, I looked to others, such as Mehan, who in 1979 fully transcribed their observed lessons. Like Mehan I fully transcribed the entirety of the science lessons, so that I could employ my modified FIAC framework throughout. The schema adopted to analyse the three cases was an extension of the FIAC design, which included descriptions of distinctive features of the teacher's practices, in the science classroom (Mitchell, 2006) (see table 5.4).

Teacher Intentions	Teacher Actions
Monitoring factual knowing or recall of subject matter	Questioning to check understanding in a different contexts.
	Questioning the ability to demonstrate subjective/personal understandings.
	Questioning prior knowledge to demonstrate task specific understanding.
Offering opportunities for learners to generate original ideas	Suggests a range of new novel ideas for learners/children to contemplate.
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them.
	Drawing on prior knowledge to enable the learners/children to look at things differently.
Evaluating the thinking and creativity that may have arisen during the lessons/learning	Asks children to critically and/or creatively reflect upon ideas and performance.
	Asks children to reflect on ideas and performances/outcomes from learning (task-led).
	Teacher articulates their reflections on learners/children's potential ideas (task-led).

Table 5. 4: A Teaching schema: characterising teacher actions within a science lesson

Teaching for Creativity	Teaching Creatively	Expositional Teaching

Key to table 5.4 above: Colours depicting the teaching practice to which the teacher intentions are associated.

Within my schema there are three main categories, or teacher intentions (see table 5.4, right hand column). The first category, monitoring factual knowing or recall of subject matter, was outlined earlier in the methodology (a further description of it can be found at section 5.6.2.3). The second (offering opportunities for learners to generate original ideas) and third categories (evaluating the thinking and creativity that may have arisen during the lessons/learning) were garnered with the CLSP definition of creativity in mind, i.e. when children '…generate and evaluate ideas and strategies…' (Stylianidou *et al*, 2014:2). As I stated before, the generalisable actions, or the sub-actions (second column) were hermeneutically construed through my on-going observations and can be related back to the descriptions of the teaching continuum which is composed of expositional teaching, TC and T4C (literature review chapter 2.2, sections B.3.1 – B.3.3).

5.6.2.4.1 Examining and reflecting upon teaching practices in science lessons through the schema

All the fully transcribed lessons and videos were initially examined three times, once for each of the main categories (left hand column, table 5.4). However upon further reflection I realised the development of this analytical tool took place when I was still very much ontologically observing the science classroom from a distance. Even Wragg (1999) recognised that the FIAC was strongly influenced by a positivist tradition. That is I, initially as a positivist, was epistemologically looking for human behaviour that could be governed by a set of rules (Edirisingha, 2012) but as my paradigm shifted I began to appreciate Edirisingha's explanation of an interpretivist:

> 'The [interpretivist] researcher remains open to new knowledge throughout the study and lets it develop with the help of informants. The use of such an emergent and collaborative approach is consistent with the interpretivist belief that humans have the ability to adapt, and that no one can gain prior knowledge of time and context bound social realities (Hudson and Ozanne, 1988)' (Edirisingha's, 2012: para.47-50).

Thus, as I immersed myself into my research, through the literature and as a school assistant, I began to adapt to the realisation that these pre-defined categories being sought through the transcript and video would not fully explain the complex, multiple and unpredictable perception(s) of reality found within one science lesson (*ibid*). Therefore this system of categorising the teachers' practices would require further consideration and expansion beyond their original fixed term descriptions. This acknowledgement of the inefficiencies of my fixed research design began by examining the transcripts and video 3x3 times, that is, once through each of the main categories (table 5.4) and then through the lenses of three individual key aspects of creativity, these being verbal exchanges, risk-taking and autonomy. How these traits of creativity were chosen, to form part of my observational framework, is described below.

The three key traits emerged through an examination of five key pieces of literature (Alexander 2010; Cremin *et al,* 2013; Glauert and Manches, 2013; Rose, 2009; NACCCE, 1999) by studying the key words and phrases that arose within each of these through Strauss and Cohen's (1998) three steps (Patton, 2015) (this approach has been previously explained in section 5.6.1.6.2.3). General descriptors of creativity or being creative were inductively sought from each key document. From this the top five categories from each piece of literature was compiled and synthesised into a table (see table 5.5 below) of ten themes.

Themed Category (key word)	**Key piece(s) of literature themed category described in (n = the number of key pieces of literature which described the themed category)**
Generativity	Alexander 2010; Cremin *et al,* 2013; Glauert and Manches, 2013; Rose, 2009; NACCCE, 1999 (n=5)
Evaluative	Alexander 2010; Cremin *et al,* 2013; Glauert and Manches, 2013; Rose, 2009; NACCCE, 1999 (n=5)
Verbal exchanges	Alexander 2010; Cremin *et al,* 2013; Glauert and Manches, 2013; Rose, 2009; NACCCE, 1999 (n=5)
Risk-taking	Cremin *et al,* 2013; Rose, 2009; NACCCE, 1999 (n=3)
Autonomy	Cremin *et al,* 2013; Rose, 2009; NACCCE, 1999 (n=3)
Problem-Solving	Alexander 2010; Cremin *et al,* 2013 (n=2)
Persistence	Alexander 2010 (n=1)
Resources	Rose, 2009 (n=1)
Knowledge	Glauert and Manches, 2013 (n=1)
Product	NACCCE, 1999 (n=1)

Table 5. 5: Depicting which of the five key pieces of literature (Alexander 2010; Cremin et al, 2013; Glauert and Manches, 2013; Rose, 2009; NACCCE, 1999) inductively describe ten theorised categories of creativity (and/or being creative)

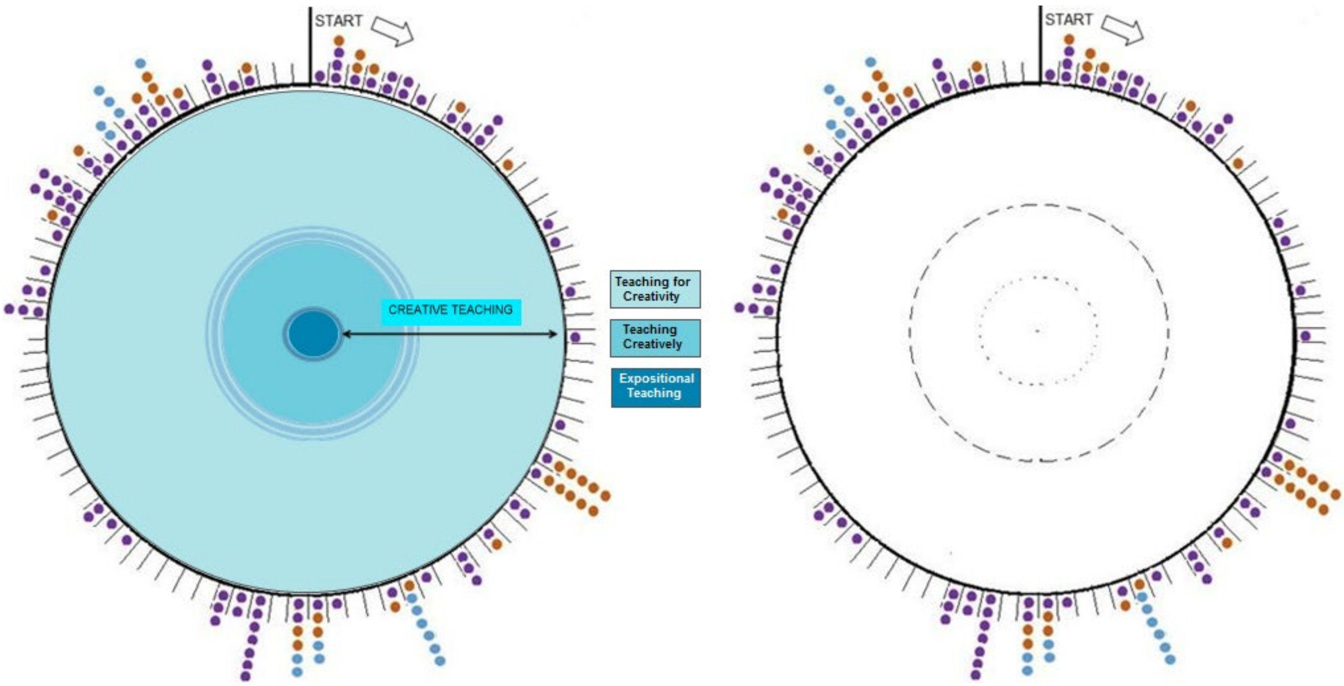
The top five key words from table 5.5 were initially intended as the lenses through which I would examine the practices of the teachers, through the schema. However ‘generating ideas and evaluating them’ had already been incorporated into the developed schema. Thus these were discounted and the individual key aspects of creativity through which I chose to examine the practices of the primary school science teachers became verbal exchanges, risk-taking and autonomy. These facets will be individually examined through the observation schema and subsequently reported, in their respective results chapter, in the opposing order (autonomy first, followed by risk-taking and finally verbal exchanges) for reasons that will become apparent in chapter 7. My interpretation of each of these key aspects has been described in more depth in the literature review, chapter 2.2-B.1.1.2 - B.1.1.4.

I feel it is imperative, at this point, to recognise that these three aspects cannot, by themselves, stand alone and represent the development of creativity (Lipman, 2003). For these traits are only three of the many interwoven elements and complex components of creativity (Robinson, 2009) that, on their own, can only provide insights into how a teacher may develop the creativity of their students. Thus I recognise this observational framework still requires further contemplation.

Screen shots of the observational templates post-analysis (from case B) can be found in the appendices (Appendices 5.H-J). It was post analysis that I considered how the observational templates from each lesson could be transposed on to figure 2.2 (a diagram which suggests the extent to which there are opportunities for developing creativity in teaching practices), which is found within the literature review (chapter 2.2-B.3.1). Once transposed it graphically represented the development of creativity throughout one primary science classroom. The creation of this graphical outcome is described in more detail in the following section.

5.6.2.4.2 Creating graphical illustrations from the observational schema

Whilst I reflected upon the observation framework (table 5.4), I returned to my literature review and figure 2.2 was brought to my attention. I then realised that the question frequency timeline (reference section 5.6.2.3) could be transposed onto the perimeter of figure 2.2. The following illustrations are case A's question frequency per minute from figure 5.2 on the periphery of figure 2.2 (see figure 5.3a) and then figure 5.3a conceptualised as a blank observation template (figure 5.3b).



(a) *(b)*

Figure 5. 3: Case A's timeline of question frequency (per minute) on the observational template

The timeline of the lesson (from start to finish) is depicted on the circumference and is illustrated through the types of questions (closed, open or pseudo-open) that were asked, by the teacher, as the lesson progresses, minute-by-minute. Figure 5.3b provides the template that can be used to graphically display each of the post-analysis observational datasets (see appendices 5.H-J for snap-shot examples). Figure 5.4 below illustrates, post-analysis, how far I have interpreted the teacher was monitoring her pupils factual knowing or recall of subject matter during a science lesson (i.e. the first main category of table 5.4), minute-by-minute, via a single theoretical lens, (i.e. through the verbal exchanges taking place during the lesson).

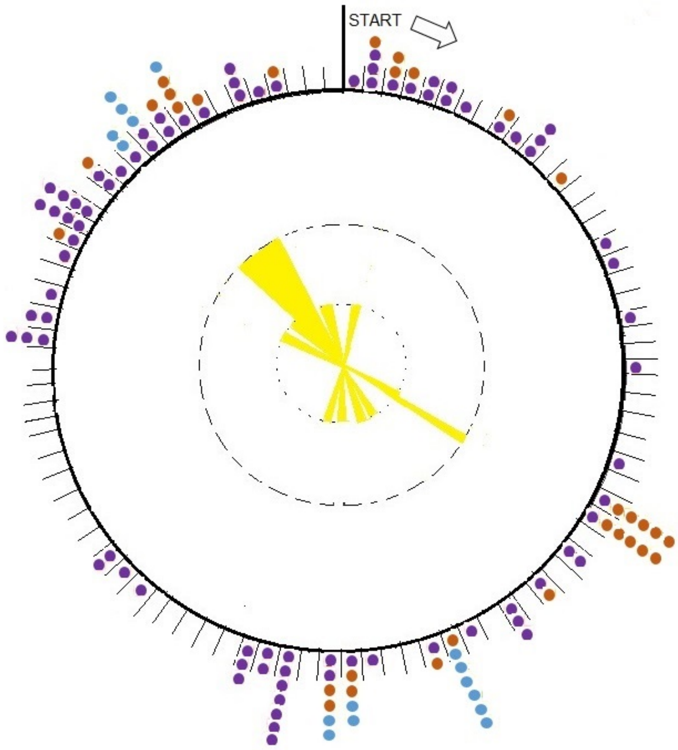


Figure 5. 4: Case A: Monitoring factual knowing through verbal exchanges

The graphical illustrations of the two other main categories of table 5.4 (i.e. offering opportunities for learners to generate original ideas and evaluating the thinking and creativity that may have arisen during the lessons/learning) through verbal interactions can be found in chapter 7 (see figures 7.8b-c). In the same chapter there are three other graphical illustrations relating to how the teacher encouraged autonomy through the three main categories (see chapter 7, figures 7.2a-c) and another triage of representations illustrating how the teacher fostered risk-taking during the same science lesson, again through the three main categories (chapter 7, figures 7.5a-c). This produces nine individual starburst-like illustrations which represented how the teacher developed creativity through the features characterised on table 5.4, during one whole (i.e. the same) science lesson in minutes, from start to finish.

It was my intention to indicate, through these observational illustrations, that the extending radii, and greater area covered, represented by the lines/blocks of colour, could represent the increasing opportunities made available, by the teacher, for the child to be expressively creative during the science lesson through their practices (i.e. expositional, TC and T4C).

In figure 5.4 we can see graphically how the teacher verbally encouraged the creative development of her pupils through the devised schema (table 5.4) on a minute-by-minute basis. For example in minute 2, i.e. the third of string dots which is represented by one closed question (one purple dot) and two pseudo open (two brown dots) the teacher would have (according to the devised schema) questioned the children's ability to demonstrate their prior knowledge in order to demonstrate task specific understanding (i.e. the yellow line extends across the inner circle only). Excerpt 5.2 (below) provides the transcript of this time period.

Teacher	There was a spark and it happened because the one piece of rock was not a pure piece of flint but it was a rock that had little bits of metal in it and sometimes you can see the rock and you can see the little shiny bits, those are little bits of iron, bits of metal in the rock, cause, do you know all rocks are different. There are so many different sorts of rocks and there are people who collect rocks and there are people who study rocks. And our hunter gatherer people will be making their tools and when the spark fell, sometimes it just might have fallen down on the ground and fallen onto something very dry, like a bit of moss, or a bit of wool and what would you think would happen, if a spark fell on there? I was not trying to let a spark fall on there. What do you think might have happened?
Child	It might have burnt.
Teacher	It might have burnt, so it might have made, what?
Child	A fire.
Teacher	It might have made a fire and that's exactly what happened, they made a fire and that's the very first thing that people had to light their homes, fire.

Case A: Excerpt 5.2

The above excerpt highlights a question which was asked after the teacher had demonstrated how iron (in a rock), after being exposed by a quick knock by a piece of flint, converts this friction into heat, and upon exposure to oxygen from the atmosphere can ignite a spark. She asked the children to consider *'what do think might happen, if a spark fell on there [onto the dry moss she was holding]?'* (lines 34-35). This required the children to express their ideas/perspectives of what may (or may not happen) when a spark fell onto moss. According to Brown and Edmondson (1984) this could be classified as a conceptual/subjective question, i.e. they were not just reciting rote knowledge (Alexander, 2008) because, as far as I am aware, this concept had not been previously taught (Wiliam, 2011). If this was the case, and table 5.4 is considered, the yellow line in figure 5.4 (situated extending towards the coloured dots that represent the question asked by the teacher in minute 2) should have extended through the second concentric circle to represent a teacher affording the children the opportunity to demonstrate their understanding (they would have been TC), however, instead the yellow line stretches across the inner circle only. To explain this I refer back to Hardman's (2008) suggestion that a teacher could know the answers they are looking for, and through my interpretation of this excerpt it appeared that the teacher was inviting the children to proffer these ideas in order to demonstrate task-specific understanding (not their subjective understanding). For example, when a child answered '*It might have burnt'* (line 37) the teacher directed the children's attention to her preferred response by asking a further question *'It might have burnt, so it might have made, what?'* (line 38). Brown and Edmondson (1984) referred to this as a nose-dive sequence of questioning, whereby the teacher begins with an evaluation question and then moves straight to recall. After receiving the favoured answer '*A fire'* (line 39) the teacher continued to tell her story of the history of light without further consultation with the pupils.

I am not the first to represent qualitative data graphically, for example Slone (2009) created a spectrum to represent internet users' goals in relation to their search duration. These goals were broken down further into mini-representations of search patterns. More recently Lucas *et al,* (2013) adopted a circular graphical representation as a tool so that teachers and/or pupils could formatively assess 15 sub-dispositions of creativity along three dimensions. Both of these studies adopted a framework which was something akin to my illustrations of creative practice when examined through my schema (table 5.4). From an historical perspective though, neither Slone, Lucas *et al,* nor I were the first to illustrate data in such a manner. In the 19th century, after returning from the Crimean war Florence Nightingale created Coxcomb diagrams, these illustrated the death toll of soldiers from diseases, as opposed to death toll from wounds which were preventable. As the number of deaths increased so did the area of the segments. These increasing areas were used effectively to help Florence disseminate her findings and aid her fight for better living conditions in hospitals (Thomas, 2013). It was hoped that, by utilising these qualitative diagrams, in a similar fashion to Nightingale's quantitative ones they can help to answer RQ2.

5.6.2.5 Further reflections upon the Schema

Having expanded my original observational framework (the teaching schema) to include three individual key aspects of developing creativity (verbal exchanges, risk-taking and autonomy), and then disseminating it through a more public arena (Frodsham, 2015a; 2015b; 2015c), it was acknowledged that there were a number of further ways that a teacher could promote creativity within the primary science classroom. O'Leary (2014) backed this up when he stated that this type of systematic framework can '…oversimplify the complex nature of classroom interactions' (*ibid*:50), I am inclined to agree, but it is recognised that this schema could also make an analytical process more manageable. Nevertheless I still find myself turning to Denzin and Lincoln (1994), who suggested an interpretivist uses more than one empirical practice in any study. Thus, I set about seeking out the possibility of devising a framework for assessing the on-going development of creativity through a suggestion made by O'Leary (2014:50) that is, via 'the nature of classroom interactions'.

5.6.2.6 Towards a fresh analytical framework concerning the types of talk observable in a science lesson

In order to consider the verbal exchanges taking place within the observed science lessons, I would need to clarify how appropriately pitched and timely social interactions, tailored to the individual child's development, would first mediate learning, and then relate this to creativity. This has previously been examined in the literature review (see chapter 2.2-B.1.1.2). In this part of chapter 2 you will find a critique of Alexander's (2008) five patterns of (teacher-child) talk and Mercer's (2008) three types of child-child interactions. Others have adopted these frameworks, such as, Martin-Millward (2017) who applied Alexander's lesser-known forms of classroom talk to reflect upon teacher-child interactions during forest school sessions and Littleton *et al* (2005) who drew on Mercer's three types of talk to study group think in key stage 1. I have taken this further and combined both to form a more comprehensive (and visual) theoretical framework to interpret all verbal classroom communication, teacher and/or children (see table 2.1 in the literature review).

Prior to conceptualising this newly theorised framework I had discovered other analytical models of child-teacher interactions were available, for example Mortimer and Scott (2003) developed a communicative framework. Whilst some have adopted it in their research, including McMahon, (2015) and Gelmaz-Burakgazi (2015), this framework only seemed to provided descriptions of the teacher-led verbal interactions and did not drawn attention to the actual reification of learning; thus creativity-in-learning could not be illuminated through its application. Then, more recently, ‘a tool for analysing dialogic interaction in the classroom’ was offered by the Cambridge Educational Dialogue Research (CEDiR) Group (Hennessy and Rojas-Drummond, 2016). This was advertised as a tool to understand how dialogue can be used collectively (in both teaching and learning) through 33 different communicative acts, all of which were grouped within eight clusters. Whilst this framework incorporated both child and adult-led conversations it was not fully understood how each utterance (or example phrase) could contribute and reflect the naturalistic reification of creativity-within-learning.

In the literature review I have proposed a fresh theoretical framework which implies that it is only when the teacher accepts and incorporates reciprocal aspects of learning that scientific concepts can be made tangible and if necessary renegotiated (see table 2.1). I have also conceptualised how ‘exploratory dialogue’ can be construed as a discourse which reaches for an idea (and/or product) through the mutual critical and constructive negotiations of ideas. This description is akin to Fisher’s critico-creative thinking and it is this type of dialogic exchange which I have suggested reifies creativity-in-learning.

However, I do not wish to solely concentrate on exploratory dialogue, for I turn to Bird (2011), who whilst researching, the spirit of AfL (i.e. an integrated formative assessment technique which is embedded into the flow of the lesson), contemplated how various types of talk should be taken into account when examining transcripts. My research has taken Bird’s advice and kept in mind all the types (and patterns) of talk described in my literature review (Mercer, 2008, Alexander, 2008). I have also taken further council from Bird’s doctoral thesis when he suggested:

> ‘It will be worthwhile studying the transcriptions to highlight examples of illocutionary and perlocutionary acts (Austin, 1975). This is relevant because illocutionary speech-acts reveal important aspects of activity in terms of speakers’ intentions. This focuses attention on what speakers are doing through their utterances and could involve, for example, putting forward a point of view, explaining, instructing, dictating, requesting, proposing, speculating and so on. Perlocutionary acts involve how the utterances of others are received, and could include accepting, rejecting, ignoring, convincing, surprising and so on…It will be important to investigate teacher – pupil talk… whether, how, and in which practices pupils bid for identification as competent through their speech-acts and the way these are received. Examples from the transcriptions of classroom activity will be selected and

> filtered, to establish when these speech-acts happen and how they affect participation' (*ibid*: 94-95).

Similarly to Bird I have selected/filtered speech-acts and then integrated them into a *map of events* for each observation ready for analysis. I also propose that through the transcripts it might even be possible to reify creativity-in-learning whilst simultaneously examining if AfL was developed/enhanced/enriched through these kinds of exchanges (this could begin to answer RQ4). The exploration for the Spirit of AfL is described further in chapter 8 of this thesis. The creation of the events maps is described below, in the following section.

5.6.2.7 Developing a map of events

Creative practices, according to Mercer and Hodgkinson (2008), can not only be understood through exploring the nature of talk, but can also be tied into: the activities undertaken; the types of actions (teacher and pupil); the social actions; the practices mediated by the teacher, and the texts produced during a science lesson. Mercer and Hodgkinson produced a 'map of events' (*ibid*: 125-126) which highlighted (in words) sequentially the key activities/strategies adopted to mediate the social actions of both the teacher and learner from the beginning to the end of a morning classroom session. However it was Mortimer *et al* (2015) who, through a micro-ethnographic study of self-continued sequences within astronomy lessons (e.g. when the teacher represents/models the moves of the moon phases to explain observed phenomenon), captured graphically and illustrated, sequentially: the key representations of the teachers' pedagogy, their salient moves and the linking moves between each exemplified representation. It was through consultation with other researchers (Frodsham, 2015a; 2015b; 2015c) that I realised that the specific activities undertaken during the observed science lessons, the teacher's (and/or pupil's actions) and the children's verbal responses to the teacher's enquiries (the speechacts/excerpts) could be depicted in a similar fashion to Mortimer *et al's* graphical representation.

To highlight chronologically these representative moments within the science lesson, the time span of the lesson (from start to finish) was represented in its original linear format (see figure 5.2). This question frequency timespan then visually illustrated when the speechacts being analysed took place (see figure 5.6 below). These excerpts could be examined through the analytical framework developed (see 5.6.2.6), to examine the type of talk being adopted at that specific time, in the science lesson. Associated pictures which represented specific mapped activities were then used to represent the join between these excerpts to the activities employed by the teacher and the subsequent key/salient actions of the teacher and child(ren) as they occurred during these activities (see figures 5.5 and 5.6). The associated pictures (which represented specific activities) can also be transposed onto the circular timeline of case A's science lesson (see figure 5.7).

It was my intention that, by examining: the illustrated representations of creative practices, the map of time-lined specific events and also the verbal interactions taking place in the science classroom, in that sequential order, it would become possible to draw attention to the various affordances for creativity that the teachers made explicit (or made visible). Miles and Huberman (1994), in Slone (2009:491) said visual illustrations (like these) can go further than pie charts, bar charts and scatter plots, in that they show patterns within the data and the relationships between factors, cases, and categories and hence validate the analysis. Swanson and Holton (2005:342) backed this up by saying:

> 'Valid analysis requires, and is driven by, displays that are focused enough to permit a viewing of full data set in the same location and are arranged systematically to answer the research question at hand…a full data set is [however] not all of one's data, but rather, condensed, distilled data…drawn from the full range of persons, events and processes under study' (*ibid*).

Thus these graphical representations will not contain all the data but can cross-reference the illustrations created from the application of the creative schema with the teacher's actions, pupils' actions, creative activities undertaken, and choice social exchanges. However, I recognise that this representation will still not go far enough to examine the emergence of all creative realities (Sawyer, 2012) due to the subjective and personal nature of the interactive experiences taking place.

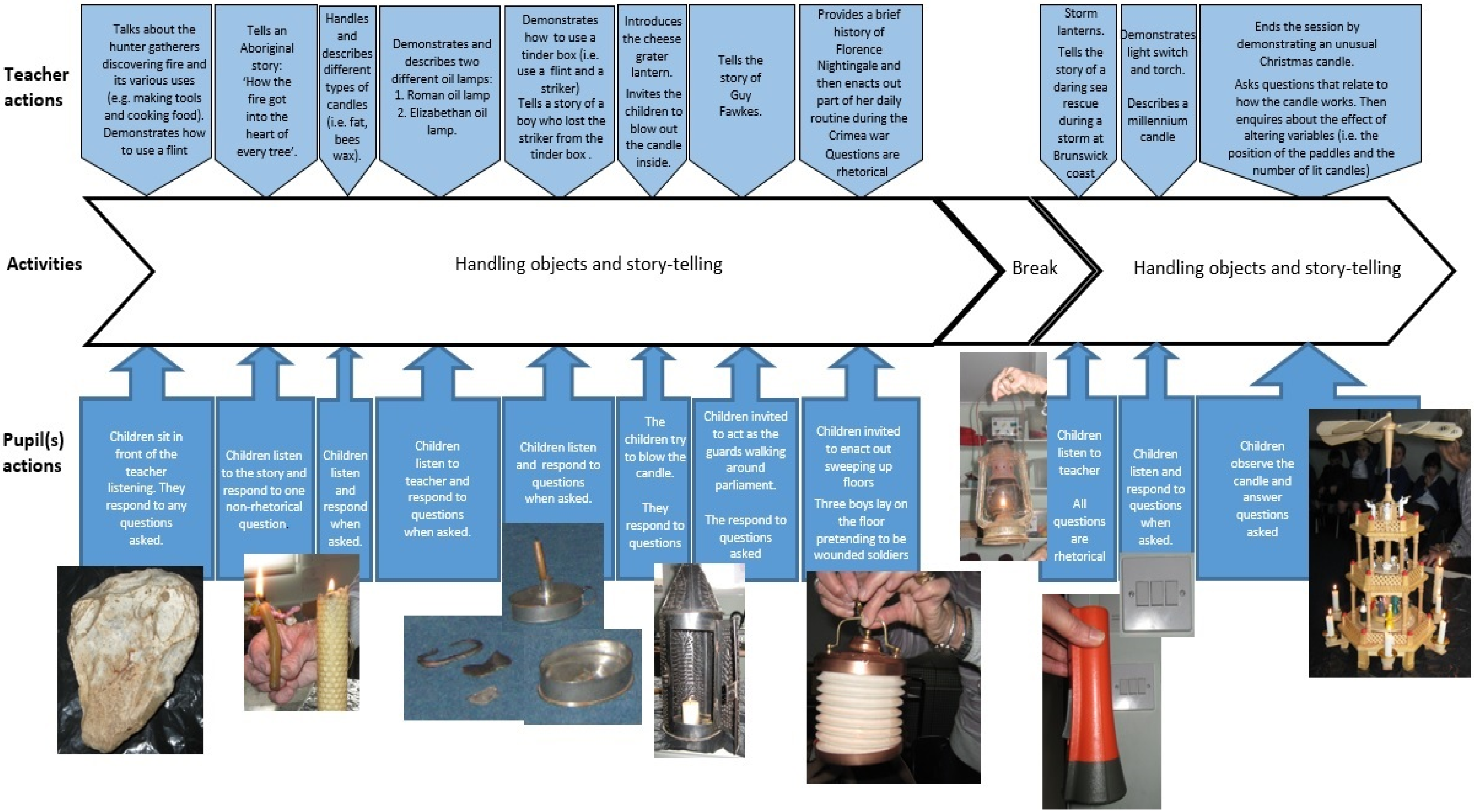


Figure 5. 5: Case A: An events map of science lesson (part 1)

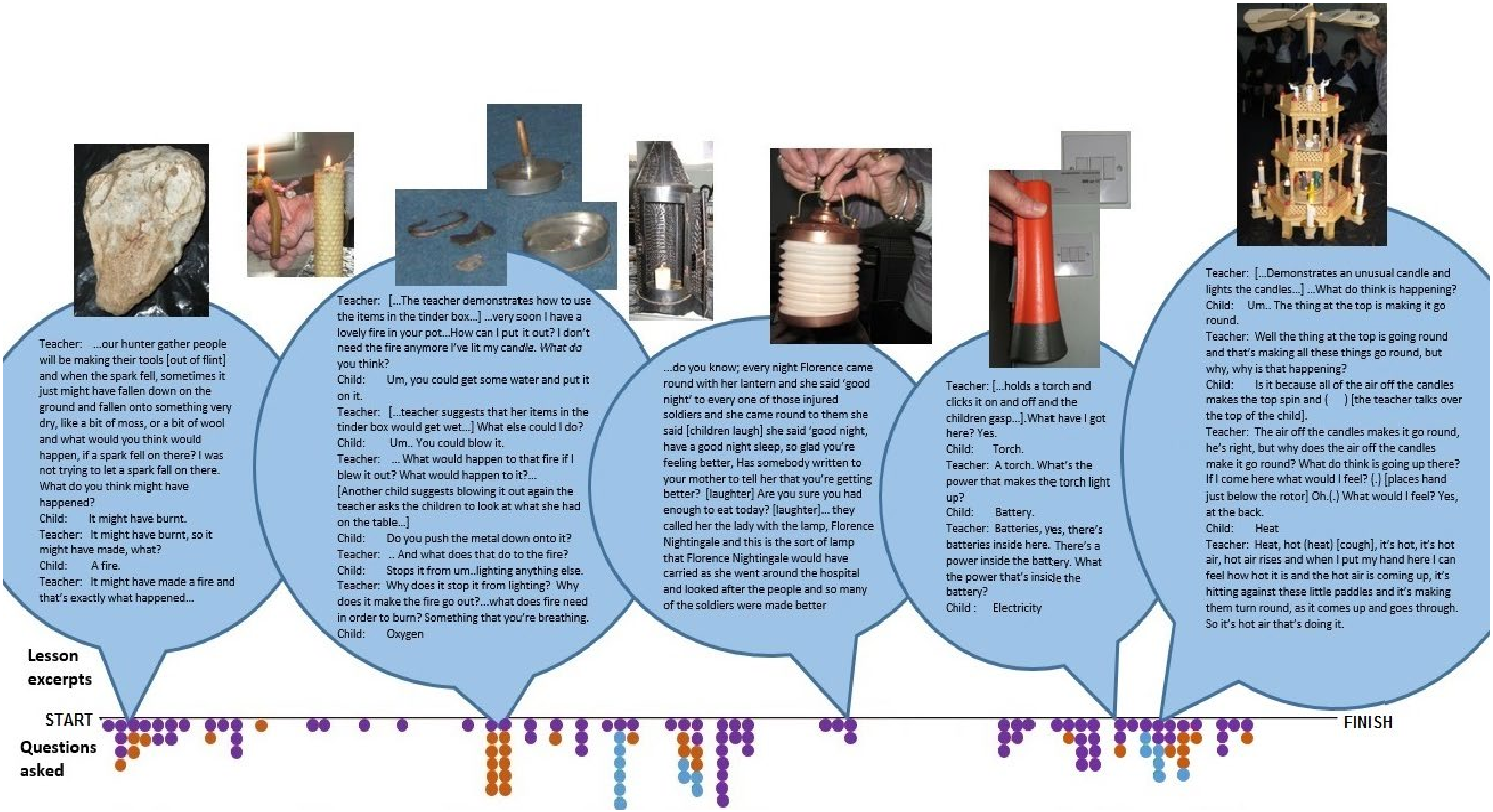


Figure 5. 6: Case A: An events map of science lesson (part 2)

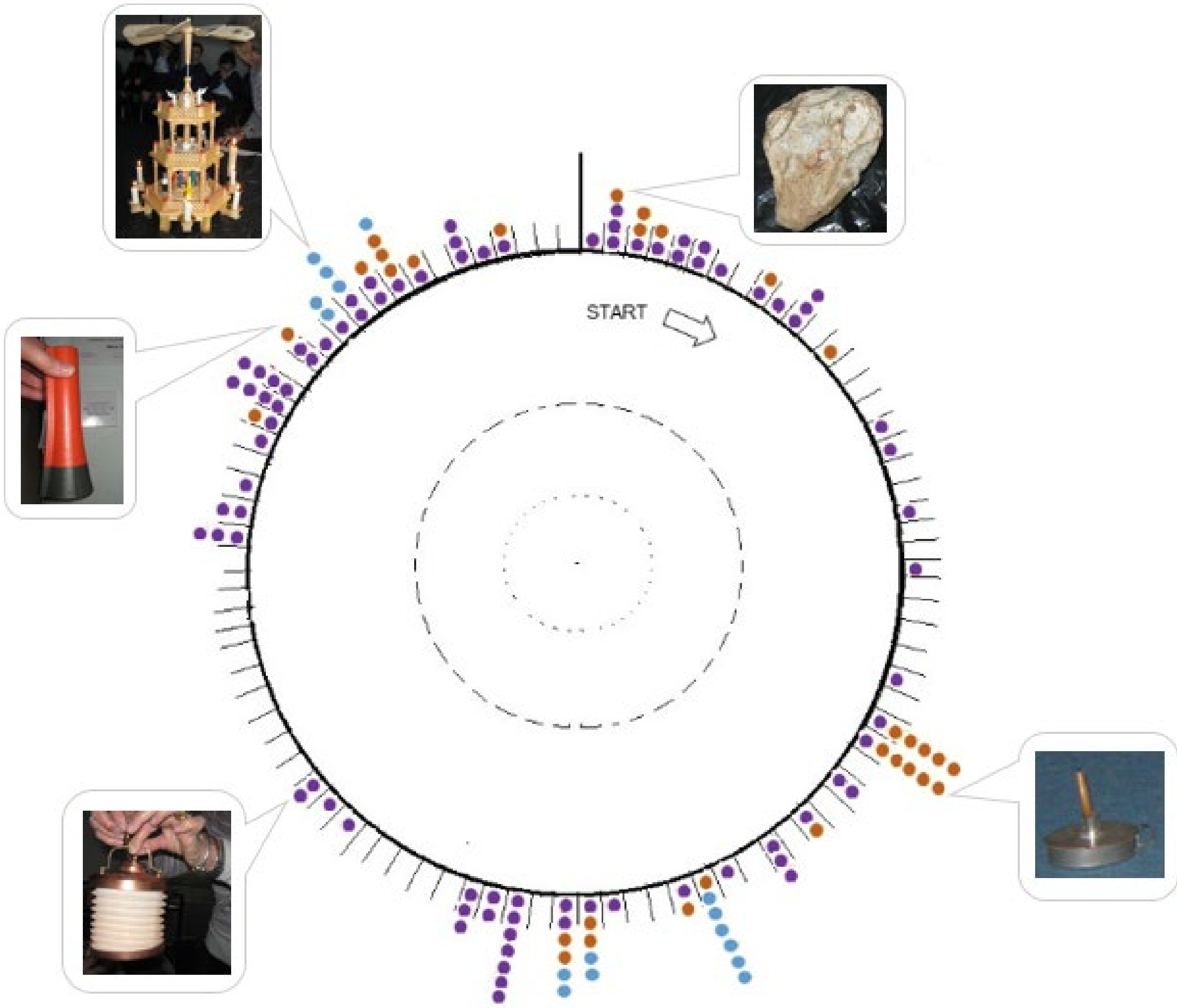


Figure 5. 7: Case A's timeline of question frequency (per minute) and associated pictures

5.6.3 Interviewing teachers

Edirisingha (2012) implies that a fixed structured design, such as my creative representations described in section 5.6.2, may not be considered interpretivist enough by some due to the 'complex, multiple and unpredictable nature of what is perceived reality'. This is backed up by Willis (2007), who is cited as saying, in White *et al* (2009), the interpretivist seeks a richer, fuller understanding of the context they are studying. To increase the validity of any claims made through these means of data collection Denzin and Lincoln (1994) suggested making other worlds visible through employing other methods. For example, by not only observing the teacher, but also by interviewing them. Patton (2015) supported this idea when he stated:

> 'We interview people to find out from them those things we cannot directly observe and to understand what we've observed. The issue is not whether observational data are more desirable, valid, or meaningful than self-reported data. The fact of the matter is that we cannot observe everything. We cannot observe feelings, thoughts, and intentions. We cannot observe behaviours that took place at some previous point in time. We cannot observe how people have organised the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things' (*ibid*:426).

Craft *et al* (2014) undertook this approach (observations followed by interviews) when they used a micro-ethnographic interpretive case study of two primary schools. Each school in Craft *et al's* study was stated to have different histories and cultures, these differences served to highlight common characteristics of creative teaching and practice. It is hoped that the analysis of interviews, surveys and observations should bring a richer deeper level of interpretive understanding to my research.

5.6.3.1 Aims of interviewing creative teachers

It was intended that the interview questions developed would elicit teachers' self-reported perceptions of the ways in which they support creativity in the primary science classroom (thereby helping to answer RQ1). They were also designed to describe and justify the range of different strategies used to assess pupils' progress in science and capture how these could (or are) be employed to evaluate creativity. This set of questions was asked to help me answer RQ3.

5.6.3.2 Approach to interviews

Craft *et al* (2014) employed a semi-structured interview within their study which, according to Merriam (2009), is the most common type of interview in qualitative research. My research also adopted this approach; it followed a formal objective, semi-structured one-to-one interview which contained eleven open (conversational) questions, these were:

1) *How would you, as a teacher, describe creativity within i) teaching and ii) learning?*
2) *Can you provide some examples, from your experience, of i) your most creative teaching and ii) the children's at their most creative during science?*
3) *What are the benefits for the children, in your experience, of i) creative teaching and ii) creative learning?*

4) *What are the challenges for you as a teacher, when developing creativity in the confines of the science lesson?*
5) *What are the challenges for the children to be creative when in a science lesson?*
6) *Do you think it is easier to be creative in other subjects, other than science? If so how and why?*
7) *In your experience, are there some children that you believe would have more (or less) of an aptitude for creativity in science than others?*
8) *How do you ignite creativity in your science lessons?*
9) *How do you currently assess the children's progress in science?*
10) *How do you currently assess the development of creativity within your science lessons?*
11) *Are there any strategies that work better to assess creativity and why?*

5.6.3.3 Developing interview questions

Having decided to adopt the semi-structured interview approach, it was initially felt prudent to perform a feasibility pilot of five questions. This took place in March 2014 (see appendix 5.L for the five questions). After the first, a second pilot interview followed, it consisted of eight questions and took place in November 2014 (appendix 5.M). Both interview schedules were originally adapted from questions devised by Craft *et al* (2014) study (see appendix 5.L).

A previous winner of the PSTA (PSTT, 2013) was invited to take part in the first pilot interview and a senior lecturer in primary school science education from Oxford Brookes University took part in a second. The aim of the pilot was to ascertain the effectiveness of the questions. This enabled me to consider the types of questions that would put the interviewee at ease and capture a more anthropological conscious side to their thoughts and ideas (Kitwood,1977 cited in Cohen *et al,* 2011). Something that was missing though the survey data (Patton, 2015). Kitwood believed that an interview will draw on a 'distinctively human element' and by doing so could add to its 'validity' (Cohen *et al*, 2011:207). However Cohen *et al* warned that by increasing validity the interviewer runs the risk of decreasing reliability. The only way to increase reliability therefore would be to control the interview by becoming '…rational, calculating and detached…' (*ibid*).

To temper the seemingly structured nature of asking the prescribed questions, to maintain a balanced duality between both validity and reliability, it was my intention that the questions would be flexible enough to allow for the interviewee to express their own opinion, without being coerced by the interviewer (Yin, 2014). They would simply be a guide which were flexible enough for the exploration of any tangents (O'Leary, 2010), through what Morrison (1993:66) called prompts and probes:

> 'Prompts enable the interviewer to clarify topics or questions, whilst probes enable the interviewer to ask respondents to extend, elaborate, add to, provide detail for, clarify or qualify their response, thereby addressing richness, depth of response, comprehensiveness and honesty…hallmarks of successful interviewing.' (*ibid*).

Thomas (2009:164) seemingly concurred with Morrison when he stated that this was a '…hallmark of the semi-structured interview [i.e.] if you want to know more…you ask about it', this way the interviewee could further reflect upon and qualify their ideas surrounding their views of creativity in the science classroom. The process of attempting to achieve this gold standard in semi-structured interviews was achieved through reflecting upon the questions post-pilot interviews, in a similar fashion to the piloting of the survey questions.

The sequence of questions was then placed in an order akin to the survey, whereby the ones that related to creative practice were placed first, followed by the questions which enquired about assessment and evaluating creativity (see section 5.6.3.2 for the 11 main phase questions). Appendix 5.K attempts to depict the possible cross-sectional analysis available between questions from the survey and interviews, whilst indicating how each of the main phase interview questions were designed with the RQ's in mind.

<u>5.6.3.4 Inviting teachers to participate in the interview</u>

Main phase interviews took place between July 2015 and January 2016. The three interviewees invited to take part were the same three creative practitioners observed and videoed previously (in cases A-C). I intended, through these interviews to appreciate what could (or could not) be directly seen through the observations (Patton, 2015). Two further teachers, who were involved with the TDTSP (a project which is described in section 5.6.1.4) were also invited to answer the devised interview questions (cases D and E). They were also the additional teachers whose science lessons were observed and scrutinised to ensure the reliability of my observational framework. This additional gathering of data allowed me to test the dependability of my interview questions (Patton, 2015). Having reflexively considered all five interviews I decided to focus my attention on three cases (A-C) for it was their observations that have been originally contrasted to illuminate the distinctive features of expositional teaching, TC and T4C (as described in section 5.6.2.1) and it was these characteristics I wanted to highlight through the interviews. All the teachers agreed to take part and were interviewed at a time of their convenience. Once the interviews had taken place they were all fully transcribed and analysed, as described in the following sections.

5.6.3.5 Analysing the interviewee's responses

All five interviews were fully transcribed but only cases A-C were entered onto Nvivo software ready for coding. The responses from the three interviews were examined twice, first each of their answers was inductively analysed (Brewer, 2000) using a grounded approach. It was intended that this would elucidate what could (or could not) be illustrated through the observational schema or survey data (Patton, 2015). This was followed by an examination of the responses from interview questions 2, 8, 9, 10 and 11 through two devised analytical frameworks. These classification systems have been previously employed to analyse the survey data (see section 5.6.1.6). All interview questions were triangulated with those found in the survey (see appendix 5.K). According to Thomas (2009) using both methods of analysis (inductive and deductive) would increase the validity of the data collected. The findings from this two pronged examination can be found in chapter 9 of this thesis.

In the following section I describe how I approached the grounded theory. Then I make it known how questions 2, 8, 9, 10 and 11 were analysed by adopting the framework originally devised for examining the data gathered from the survey.

5.6.3.5.1 Examining interview responses through grounded theory and analysing teachers' responses through a devised framework

According to Scott (1996:77) grounded theory '…proceeds in a series of steps', and previously we have encountered these through Strauss and Cohen, who listed these as: basic description, conceptual ordering and then theorising (Cohen *et al*, 2011), see section 5.6.1.6.2.3. However, others, such as Bartlett and Payne (1997) have suggested up to ten processes/phases, which include: collecting data, transcribing data, developing categories, saturating categories, formalising abstract definitions, theoretical sampling, axial coding (developing and testing relationships between categories), theoretical integration, grounding the theory and then finally, filling in the gaps. Scott (1996:77) went on to say that '[i]t was never intended that these [Bartkett's and Payne's] steps should be understood as a rigid prescriptive, since the researcher may choose to go backwards or forwards, or to spend more time on some rather than others'. Scott's description of Bartlett's and Payne's ten phases is arguably the procedure that the researchers took in Craft *et al's* (2014) study, where, after the observations and interviews were fully transcribed, the researchers coded the transcripts line by line. This is an inductive approach, according to Corbin and Strauss (2015). Then they '…undertook axial coding, naming themes that emerged from the initial coding, followed by comparison, pattern analysis and engagement with wider literature' (Craft *et al*, 2014:22). It is my intention to approach the interview data in the same flexible manner as Scott's description. This inductive approach naturally lent itself to analysing all the responses from all 11 of the interview questions. The specifics (or the detail) of this examination can be found in chapter 9 of this thesis.

The deductive analysis of the responses from questions 2 and 8 was a two-pronged approach, the same method utilised here was applied to the self-reported episodes of creativity garnered from questions 8, 9 and 11 of the survey (see section 5.6.1.6.2.2). The answers pertaining to how the teachers' currently assessed learning and/or creativity (questions 9, 10 and 11) were scrutinised in a similar fashion as the responses to questions 15-17 of the survey (see 5.6.1.6.3.2). This analytical process is explained in greater depth in chapter 9.

Having now described how the data was collected through three different methods (the survey, observations and via interviews) and then subsequently explained how these data-sets were critically examined I needed to acknowledge my interactions with the participants. This is important because Scott (1996:68) claimed that I, as an interpretivist researcher, would need to recognise the collection of the data as a complex social activity. Thus I need to be aware of the relationship between the ethical issues arising, due to manner in which the data was collected, and my epistemology. This, Scott continues, leads to having to confront a series of dilemmas. These ethical quandaries are described in further depth below.

5.7 Ethical considerations

Miles and Huberman (1994) agreed with Scott's view that epistemologically ethics is not governed by a set of easy to implement rules (much to my inner positivist's disappointment), they state that:

> 'Many of the accounts we've read of ethical dilemmas in qualitative studies describe "compromises", "trade-offs", "balances" and "unhappy choices". If ethical issues were clear-cut and totally approachable on a deontological basis, life would be simple. But we have to keep thinking and talking about

> ethical dilemmas, weighing how we and our respondents are choosing one side or another' (*ibid*:296).

So whilst I will describe my ethical choices below, I do so not to undermine these ethical predicaments but to highlight how I perceived myself, as a researcher, making decisions which concerned the rights and responsibilities of both myself and the people being researched.

As a researcher I agreed with Denzin and Lincoln (1994:144) when they stated that

> '…research subjects have a right to be informed about the nature and consequences of experiments in which they are involved. Proper respect for human freedom generally includes two necessary conditions. First, subjects must agree voluntarily to participate – that is, without physical or psychological coercion. Second, their agreement must be based on full and open information' (*ibid*).

However, before approaching any potential participants written requests were sent to the Headteacher because, as Cohen *et al* (2011) indicates, there is an 'issue of advocacy'. These letters of introduction contained information which clarified the nature and methods of my research. To ensure participants were then not subsequently 'railroaded' (Cohen *et al's* words) by the school principal (*ibid*:80) the teacher and pupils also received personalised (age appropriate) information sheets, at each stage of the research prior to data collection, i.e. when answering the survey (teacher only), before the observation (teacher and pupil), and prior to any interviews taking place (teacher only). These information sheets contained information which was akin to the initial introduction/request letter sent to the Headteacher, except they specifically referred to the method of data collection being undertaken. The parents received a fair processing notice one week prior to any data being collected which involved the pupils (i.e. when videoing observations). This notice also included information pertaining to what action the parents/guardians should take if they did not want their child to be filmed.

Cohen *et al* (2011:228) highlighted how 'relationships between researcher and the researched are rarely symmetrical in terms of power; it is often the case that those with more [perceived] power, information and resources research those with less'; this is never more so obvious between adults and minors. I was consciously aware of this asymmetry between researcher (the adult) and pupil (the child), so to ensure the children understood the implications of the research their personal information was read individually, by the pupil, in their own time. They were then asked, by the teacher (the known adult) if they had any questions regarding the filming of the lesson or my research. Lastly, and for a second time, the pupils were asked to consider whether they would like to participate (or not) before they signed their consent forms and the filming started.

Informed consent was sought from all participants (adult and child) before data was collected because as Cohen *et al* (2011:77-78) states this 'is a cornerstone of ethical behaviour, as it respects the right of individuals to exert control over their lives and to take decisions for themselves'. According to Diener and Crandall (1978:57) it is defined as a 'procedure in which individuals choose whether to participate in an investigation after being informed of the facts that would likely inform their decision'. These 'facts' being found on the information sheets.

The participating schools, teachers and their pupils were treated with the upmost confidence at all times. This level of anonymity was described in all information sheets (including the Headteachers introductory letter). Cohen *et al* (2011) called this a 'standard protection' (*ibid*:228) and Denzin and Lincoln (1994:145) referred to as '….the primary safeguard against unwanted exposure'. This involved 'withholding participant's real names [i.e. the school's, the teachers, and the pupil's names] and other identifying characteristics [such as school logos]' (Cohen *et al,* 2011:228). In this case the anonymity of the schools studied, the staff members of the school, the actual teacher being studied, plus the pupils were protected through assigning case designations (A-C).

At every step (verbally and through the information sheets) they (the teachers and pupils) were reminded that taking part was voluntary and the school, the individual teachers and any of the pupils could decline to take part if they wished, without stating a reason.

By interacting with all participants, through the information sheets and consent forms, in this manner, before employing the chosen methods of data collection, I understand that I, the researcher, will have a direct effect on the participants and as Scott (1996:69) claims there is an 'inevitable interlocking of the epistemological and ethical dimensions' and this was considered when examining, exploring and triangulating the data collected.

Chapter 6

Reviewing survey responses: Analysing teachers' self-reported creative practices

6.1 Aims of surveying creative teachers

This chapter will examine the responses of the teachers to the survey questions related to the nature and extent of creativity in their practice (see appendix 5.C). The approach adopted and the methods employed to analyse the data collected have previously been described in the methodology chapter, section 5.6.1. Whilst the survey initially set out to gain insights into various teachers' creative practices, it later became apparent that gathering this information was pertinent to this research because a study (previously outlined in chapter 5.5) by Johnston (2007) recognised that ten pre-service primary school teachers (who had received specialist training in primary science) when planning for a discovery science lesson, had described their practice as actively involving the learner. However, when these teachers were observed these lessons were, in fact, teacher-led. This discrepancy between data-sets (surveys and observations) only serves to highlight the necessity of collecting data through more than one interpretative practice (Denzin and Lincoln, 1994).

6.2 Garnering self-reported teacher's views of fostering creativity in primary science lessons

The survey consisted of three sections (A, B and C, see appendices 5.C), and was distributed in April 2015 to PSTT college fellows and schools involved in the PSQM scheme (see chapter 5.6.1.5). By the beginning of July 2015 101 surveys had been completed and returned. The responses collected were examined to gain an understanding of how primary school teachers describe and promote creativity in the science classroom (section B), and to explore how (or if) the teachers formatively assess creativity during science lessons (section C). Findings from this examination are presented in the following sections below, first section B (6.2.1) followed by section C (6.2.2). Section A, asked for demographic data (i.e. gender, years of experience etc…); this data has been previously reported in chapter 5, section 5.6.1.6.1.

6.2.1 Gaining insight into teacher self-reported views of creativity (i.e. examining responses from section B of the survey)

Section B of the survey consisted of 12 questions. The first seven were closed and the data gathered from the teachers' responses can be found in the next section (6.2.1.1). Following these there were five open questions which were designed to garner descriptive accounts of the teachers' creative practice. These self-reports of creativity were examined using a devised analytical framework (see 6.2.1.2) and they provided further insights into the ways teachers reportedly fostered creativity in their science lessons.

6.2.1.1 How frequently teachers support seven specific aspects of creativity

The first seven likert-scale questions focused the teachers' attention on how often they believed they supported the development of creativity through specific features. A more extensive justification of these characteristics (i.e. curiosity, asking questions, coming up with ideas, reflecting upon ideas, thinking independently, overcoming challenges and creating something new) can be found in chapter 5.6.1.3.2. Below (in table 6.1) is the data summarised from teachers' responses. All 101 teachers completed this section of the survey.

Questions	Frequently (%)	Sometimes (%)	Never (%)
How often do you support the children to ask questions in science?	90	9	1
How often do you support the children to develop curiosity in science?	80	20	0
How often do you encourage the children to think independently in science?	77	23	0
How often do you support the children to overcome challenges in science?	68	32	0
How often do you support the children coming up with ideas in science?	67	33	0
How often do you support the children to reflect on ideas in science?	63	35	2
How often do the children create something new (poem, song, enactment, individual experiment etc) in science?	28	67	5

*Table 6. 1: Frequency of teachers who believed they supported creativity through seven particular skills *adapted from Oliver, 2006*

The most frequent response was *encouraging questioning*; 90% of the teachers stated that they did this frequently. The vast majority (80%) then claimed they also nurtured *curiosity*. However, I recognise that there are varying definitions of curiosity available (Schmitt and Lahroodi, 2008) and these cannot be differentiated through a closed question. Teachers then reported that they also enabled the children to *think independently, overcome challenges, come up with ideas and reflect upon their ideas* frequently (77%, 68%, 67% and 63%, respectively). Interestingly, teachers appeared to think that they provided much less opportunity for the children to *produce something new* (or novel) within the science lesson: the majority of practitioners (67%) reporting that this occurred sometimes, whilst 5% admitted that this never transpired at all. These findings resonate with Frodsham *et al*'s (2014) study where primary school pupils described making products which were already prescribed by the teacher.

Questions 8-11 were more open, and were designed to gather fuller, richer descriptions of the teachers' practice. The examination of these responses, it is hoped, will offer descriptive illustrations of the ways that the teachers have promoted creativity through their practice, thereby responding to research question (RQ)1.

6.2.1.2 Applying Oliver's (2006) ten ways of making science teaching creative to interrogate teachers' descriptions of their practice

Questions 8-11 were originally designed to garner the notable practices which held value for the teachers. By reflecting upon the responses to these questions it was intended that the nature of the teachers' creative practices in their science lessons could be illustrated. The teachers' responses to these four questions were examined with my interpretation of Oliver's ten ways to be creative in science, in mind (see literature review 2.2-B.2.1 or appendix 6.A for a summarised description of these categories).

Below the eighty-third survey returned provides an example (from the teacher's response to question 8) of a self-reported activity which was analysed and subsequently considered to illustrate several of Oliver's categories. This example, whilst lengthy was:

> Response 83: 'I gave them all a 'special science bracelet', asked them to wear it all day and then try and explain what made it special. It was made of UV beads that change from white to bright colours when in UV light. Most thought it was temperature that changed the beads because it was a cold, cloudy day and they changed colour at breaktime when they were outside. I asked them to take them home and test them too. Many came back the next day saying it was light that made them change because they had been outside in the cold (but dark) evening and the beads hadn't changed colour. Following this, I

> asked them to predict what would happen if we sprayed the beads with suncream, then we did this and drew out the similarities between these beads and our skin - now they understand why they need to wear sunscreen! 6 months on, many children are still wearing their special science bracelet every day!'

In the above response, the pupils were given a seemingly recognisable piece of jewellery (a bracelet) and were asked to consider why it changed colour throughout the day (including at home). Whilst this reported activity does not inform how the pupils worked together (e.g. individually, in small groups, or as a whole class etc…) it does, according to the teacher, reportedly offer the pupils the opportunity to proffer their own ideas and reflect upon their reasoning, (e.g. when they considered temperature and/or light changing the colour of the beads). Following the generation of these initial ideas the teacher invited the children to think further by first asking *'them to take them [the beads] home and test them too',* and then, the following day, asking them to predict what would happen if they *'sprayed the beads with suncream'*. The teacher finally suggested that they '*drew out the similarities between these beads and…skin'*, she went on to suggest that *'now they understand why they need to wear sunscreen!'.* As stated before, after consideration my analysis of this reported activity would suggest that the activity, as described, appeared to illustrate seven of Oliver's categories. These are:

1) T*urning predictable outcomes into something better.* This occurred when the seemingly common place (e.g. the application of sun-cream) was made intriguing by being applied to the beads rather than human skin.
2) *Making the ordinary fascinating.* Fascination could be stimulated by the bracelet's beads changing colour and then there are also the comparisons between the changes in colour due to the varying conditions (day versus night, sun-cream versus no sun-cream).
3) *Seeing things differently*. The children are provided with opportunities to observe the beads change colour in varying different situations (at school and then at home, during day and at night). Then there is also the varying (alternative) interpretations of the same investigation to be considered, e.g. the change in the beads colour due to temperature and/or light.
4) *Maximising opportune moments*. The teacher reportedly provided various opportunities for the children to connect their ideas to the scientific through a series of observations, in different conditions (day/night, with/without sun-cream).
5) *Modelling explanations.* The application of the sun-cream to the beads followed by the lack of colour change will, according to Oliver, help illustrate the connection between scientific theory and practice.

6) *Encouraging autonomy.* The pupils were asked by the teacher to examine the beads and *'to try and explain what made it special'* in different environments, e.g. the playground and when she *'asked them to take them home and test them too'.* Thus while the teacher is initiating the activity the children are being encouraged autonomously to think about, observe and consider how to explain the colour changes they see.
7) *Allowing for flexible beginnings*. Whilst the teacher's description implied that there was a specified beginning, that is the teacher guided them to take the bracelet home to observe and consider the colour changes that took place; the children were left to choose the variables in their investigation once the bracelet was in their possession, e.g. they could have put them in the fridge (dark and cold), on the warm window sill (light and warm), or perhaps on top of a bag of ice on the table (cold and light).

Thus seven of the ten of Oliver's ways to make science teaching creative were identified during this analysis.

It was after examining the responses from questions 8-11, through my analytical framework, and tallying the number of times each of Oliver's category was demonstrated (see tables 6.2-6.5, end column), that it became more apparent that the creative episodes described by the teachers' could be classified as either teacher or learner initiated. This was a pivotal moment in my research into creative teaching practices. In order to capture this, the responses collected were examined for a second time into sub-coded bilateral categories, these were, 'teacher-initiated creativity' (TIC) or 'child-initiated creativity' (CIC), which reflected the description of the creative episode described within the teachers' written accounts. When it was not possible to associate the response with either sub-category then they were classified as a 'creative classroom activity' (CCA). This second step in the analysis is described in greater depth in the methodology chapter (5.6.1.6.2.2). To examine who the agentive owner of the creativity in the science lesson was (the teacher or the learner) the interpretive results from each question were quantified. That is, the number of times each sub-category (TIC, CIC or CCA) was demonstrated was tallied and totaled, then converted into percentage frequencies, to more easily construe who was described as leading/initiating the activity (see final row on tables 6.2-6.5).

It is here that I acknowledge that the original survey questions either focused on the teacher's creative practices (see questions 8 and 11 on the survey, appendix 5.C) or the pupils' creative expressions (questions 9 and 10 in appendix 5.C); thus it was anticipated that the responses to these questions would more likely be categorised as TIC or CIC respectively.

In the next section of this chapter, the results of my examination (i.e. the adoption and application of the bilateral analysis of the responses collected) from the survey results are considered in numerical order (i.e. from questions 8 to 11). Following each table of results there are teacher citations from the responses to that particular question, which are used to represent illustrations of the prevailing ways (according to Ann Oliver's categories) in which the science teaching was creative. I do not examine every reported activity from each of the three subcategories (TIC, CIC and CCA) in this chapter, however, responses associated with these subdivisions (with Oliver's ten ways in mind) have been offered in the appendices (6.B, 6.C, 6.D and 6.E).

6.2.1.2.1 Examining the most creative activity a teacher has taught

Table 6.2 represents the end result of the bilateral analytical process from question 8 responses. Question 8 being '*Please describe the most creative science activity you have taught'*. Out of the 101 completed surveys 99 teachers answered this question.

Oliver's ten ways to make science creative	Number of times category demonstrated as a CCA	Number of times category demonstrated as a TIC	Number of times category demonstrated as a CIC	**Total number of times each category is demonstrated**
Turning predictable outcomes into something better	19	9	8	36
Making the ordinary fascinating	42	22	14	78
Sharing a sense of wonder	0	0	1	1
Seeing differently	43	18	6	67
Maximising opportune moments	0	4	1	5
Humanising science	2	1	0	3
Valuing questions	1	4	2	7
Modelling explanations	46	9	12	67
Encouraging autonomy	19	15	14	48
Allowing for flexible beginnings	2	3	1	6
Accumulative Total (and %)	174 (55%)	85 (27%)	59 (18%)	318

Table 6. 2: An analysis of teachers most creative science activity taught - classified according to Oliver's ten ways to make science teaching creative

The analysis of the teachers' responses to question 8, summarised in table 6.2, indicates that 55% of the reported science activities, as described by the teachers, did not clarify who (teacher or child) initiated them (noted as CCA). This was interesting because it had been anticipated previously that the responses to this question would more likely be focused on the teachers' practices (TIC) due to the phrasing of the original question. Of the remaining 45%, 27% of the descriptions were teacher-initiated, whilst 18%, reported that the children developed their individual and/or collective creativity.

The interpreted data (as organised in table 6.2) also indicate that the highest cumulative frequencies of Ann Oliver's categories (left hand column) were *making the ordinary fascinating*, *seeing differently* and *modelling explanations*. These three categories have been interpreted as focusing on the children's experiences and they purportedly provide the learners with opportunities to associate their subjective understandings with, not only the scientific, but also their natural surroundings. For example, in Oliver's (2006) description of *modelling explanations* she suggested using simple real life everyday examples (such as washing hands), this modelling of a natural occurrence places a simple image in the children's minds (an analogy) from which an opportunity to build a relationship with the scientific can be sought. This link to a familiar everyday activity can *make the ordinary fascinating,* such as the teacher drawing the children's attention to the micro-world and enabling them to see what was previously unseen (e.g. germs). It is here that the children are provided with the opportunity to *see things differently*. An example of this type of activity can be found in response 9 below (this is the response to question 8 from the ninth survey returned).

> Response 9: 'This year using cinnamon as germs (with oil) to investigate best way to clean our hands/ touching bread with washed/unwashed hands…'.

Here the teacher uses cinnamon (mixed with oil) as a way to imagine/picture the unseen germs (the microorganisms) that surround the children in their macro-environments.

<u>6.2.1.2.2 Inspecting teacher reports of children at their most creative during science lessons</u>

Following question 8 the next question on the survey invited the teacher to describe notable examples of children at their most creative. Of 101 surveys returned 94 teachers answered this question, however eight wrote the comment *'see above'*, referencing their response to question 8 (which was teacher-focused). Due to the nature of the enquiry (which was meant to be child-orientated) these reports of the teachers' creative practices were not examined. Table 6.3 is the end outcome of the analytical examination of the responses from question 9.

Oliver's ten ways to make science creative	Number of times each category is demonstrated as a CCA	Number of times each category is demonstrated as a TIC	Number of times each category is demonstrated as a CIC	**Total number of times each category is demonstrated**
Turning predictable outcomes into something better	12	0	16	28
Making the ordinary fascinating	31	3	17	51
Sharing a sense of wonder	1	0	0	1
Seeing differently	34	0	15	49
Maximising opportune moments	8	0	10	18
Humanising science	1	0	0	1
Valuing questions	3	1	7	11
Modelling explanations	27	2	13	42
Encouraging autonomy	21	6	18	45
Allowing for flexible beginnings	6	2	7	15
Accumulative Total (and %)	144 (55%)	14 (5%)	103 (40%)	261

Table 6. 3: Teachers' views of their children's creativity in science (as analysed according to my interpretation of Oliver's ten ways to make science teaching creative)

The self-reported episodes of child creativity, summarised in table 6.3, indicate that just over a half of the responses (55%) did not provide sufficient detail in their descriptions to discern who was responsible for the creative acts – a similar outcome to the findings of the previous question. This is fascinating because again it had been expected that the majority of responses would be classified as CIC.

Having analysed the teachers' reports of children's creativity, there were four of Oliver's ways to be creative in science that were most frequently cited. They were: *making the ordinary fascinating*, *seeing differently*, *encouraging autonomy* and *modelling explanations*. To illustrate this, response 67, from question 9, is considered below. This written description, from the sixty-seventh survey returned, is examined because it was associated with all four of these categories, although it is recognised that the written description itself does not clarify whether the activity was teacher and/or the child-initiated:

> Response 67: 'Building bridges using paper and sellotape only - the bridges had to hold a certain weight and could be any design'.

This activity could enable the children to build and consider how a bridge balances forces (compression and tension) to be able to support the weight travelling (or in this case applied) over the top, something they may not have considered before; thus the children would be *seeing [these everyday structures] differently,* that is, from another perspective. Here the ordinary phenomenon of a bridge could be *made fascinating.* There also appears to be an element of making decisions, exploring and playing (*encouraging autonomy*) whilst pursuing the learning goal (for the children were invited to build a bridge of any design to support a certain weight). By examining, exploring and building this bridge (to support the weight of a roll of sellotape) in this manner, a mental picture (or analogy) could have provided the opportunity to make the connection between scientific theory and practice (*modelling explanations*).

6.2.1.2.3 Teacher accounts of children at their most creative when not in a science lesson

The next question on the survey was designed to garner the teachers' descriptions of the children's creativity, in subject areas, other than science. There were 86 teachers who chose to answer this question but 21 teachers referred to science when answering this question, and so these 21 have not been included within this analysis. Finally, in order to associate the teachers' answers with Oliver's ten categories, I replaced any references to the discipline of science, within the framework, with the subject specifically mentioned in the teachers' response. Table 6.4 provides the summarised data as examined from question 10.

Oliver's ten ways to make a lesson creative…not science!	Number of times each category is demonstrated as a CCA	Number of times each category is demonstrated as a TIC	Number of times each category is demonstrated as a CIC	**Total number of times each category is demonstrated**
Turning predictable outcomes into something better	7	0	6	13
Making the ordinary fascinating	18	1	5	24
Sharing a sense of wonder	2	0	0	2
Seeing differently	8	0	2	10
Maximising opportune moments	3	0	0	3
Humanising the subject	1	0	2	3
Valuing questions	2	0	0	2
Modelling explanations	12	0	0	12
Encouraging autonomy	13	2	5	20
Allowing for flexible beginnings	3	0	0	3
Accumulative Total (and %)	69 (75%)	3 (3%)	20 (22%)	92

Table 6. 4: Summary of teacher responses to a request for descriptions of the most creative thing their children have ever done in a lesson…but not in Science! - with Ann Oliver's ten ways to make science teaching creative in mind

The summarised data from table 6.4 indicates that the majority of the reported creative episodes (75%) from disciplines other than science could not be clearly defined as teacher or child-initiated, that is, I cannot be sure from whom the creative acts originated. The remaining 25% of the responses, when sub-categorised into bilateral categories, are reportedly 3% TIC and 22% CIC. Because of the phraseology of the original question it is this latter sub-category (CIC) which was anticipated to be the most commonly described by the teacher. Interestingly, practitioners not distinguishing between their practices and their pupils' creative expressions appeared to be a reoccurring phenomenon. This has been inferred by referencing the findings from the previous questions (see tables 6.2 and 6.3) and will be considered further in section 6.2.1.2.4.

This was an analysis of the teachers' views about children's creativity outside science, so the subjects specifically mentioned by the teachers were tallied to elucidate which subjects were associated with creativity the most (see figure 6.1).

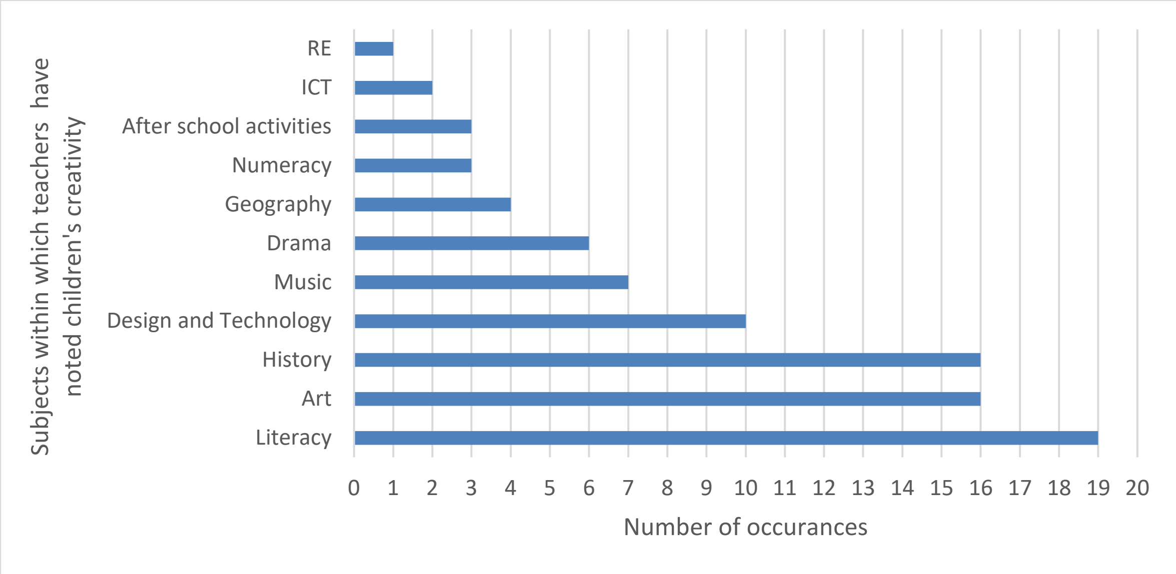


Figure 6. 1: Disciplines (other than science) in which teachers have observed the children at their most creative

The three subjects associated with the learner's creative expressions the most were literacy (n=19), art (n=16) and history (n=16). In a study performed by Davies *et al* (2004) undergraduate trainee teachers were asked which subjects provided the most scope for creativity, the top three subjects named were art, English and music. Therefore the pre-service and in-service teachers appeared to report that more creativity was evident in both art and English. Creativity was also noticed in music, by both groups of teachers, more commonly than most other subjects, but not as much as art and English. Interestingly design and technology (D&T) was also acknowledged as providing creative opportunities by the in-service teachers (n=10), but in Davies's study it *'faired poorly'* (ibid:3) with only 7% of the pre-service teachers referring to it.

It would appear that teachers persistently connected creativity with the subjects associated with the arts, such as literacy, art, history, music and drama rather than subjects such as Mathematics and ICT. This may not be that unusual when considering that UK curriculum texts referred to creativity twice as much in the arts documentation (i.e. art, music, dance and drama) than any other subject (Wyse and Ferrari, 2015). One pre-service teacher, in Davies *et al's* (2004) study, even mentioned how often the term is used in D&T documentation: *'I chose D&T because it was mentioned in the National Curriculum twice for creativity'* (ibid:3). It could be suggested that this highlights the fact that teachers do notice when it is (or is not) referred to within policy imperatives. Perhaps then the lack of written recognition relating to creativity in certain subjects (i.e. Science, Maths and ICT) through policy driven documents could influence the teachers' perceptions of it in other subject areas.

Having illuminated the subject in which the teachers noticed children at their most creative I now refer back to table 6.4. There are reportedly two dominant creative ways for a teacher to help the children to be at their most creative, in a discipline other than science, and they are by *making the ordinary fascinating* and *encouraging autonomy*. Both these categories have previously been regularly associated with the teachers' descriptions of creativity in their science classroom (see tables 6.2 and 6.3). The twenty-eighth response to question 10, is reflected upon because it incorporates both:

> Response 28: 'I once did a whole unit of work on a desert island shipwreck where my whole class created a huge desert shelter on the school field... that was pretty creative as they had very little usable materials and had to think/work together to turn natural materials into a sturdy shelter!'

The above written description appears to infer that the teacher developed and conceived of the topic (a desert island shipwreck) to initiate the activity, but it is uncertain if this task itself was teacher and/or child-led because the children reportedly '*had to think/work together',* this phraseology implying some form of teacher guidance. Nevertheless the children explored their environment (the school playing field) scavenging for natural materials to create a shelter (thus *making the ordinary [the familiar materials] fascinating*). They apparently had to work together and make decisions mutually (they were *encouraged [to be collectively] autonomous*) about these resourced materials from the world around them, for the potential use in a sturdy structure. Thus they also *'had to'* view the materials collected from a fresh perspective, to make the building secure (i.e. this response was also associated with Oliver's category of *seeing things differently*).

6.2.1.2.4 Aspects of a teacher's practice which ignite the children's interest in science

Following on from question 10 the teachers were invited to consider how they thought they kindled the children's interest in science by inviting them to answer question 11 (i.e.

Which aspects of your creative lessons has sparked the children's interest in science?). Table 6.5 contains the examined data collected from the 94 practitioners who answered this question.

Oliver's ten ways to make science creative	Number of times each category is demonstrated as a CCA	Number of times each category is demonstrated as a TIC	Number of times each category is demonstrated as a CIC	**Total number of times each category is demonstrated**
Turning predictable outcomes into something better	8	0	4	12
Making the ordinary fascinating	18	6	5	29
Sharing a sense of wonder	9	4	0	13
Seeing differently	18	3	2	23
Maximising opportune moments	6	2	0	8
Humanising science	0	0	0	0
Valuing questions	7	2	4	13
Modelling explanations	15	2	0	17
Encouraging autonomy	24	11	20	55
Allowing for flexible beginnings	5	1	0	6
Accumulative Total (and %)	110 (62%)	31 (18%)	35 (20%)	176

Table 6. 5: A summary of the analysis of the teachers' reported descriptions when they have sparked the children's interest in science.

The percentage data, as depicted on table 6.5, indicate a similar proportion of creative activities described (when compared to tables 6.2-6.4) that do not clarify whether they are clearly teacher or child-initiated, i.e. just over half of the responses to question 11 were a CCA (62%). Whilst this re-occurring finding may suggest that the teachers are not 'clearly' thinking about the distinction between features that illustrate 'teaching creatively' TC and 'teaching for creativity' T4C, it could also imply that they envisage both practices as being intertwined. However, this is speculative because the data collected is not detailed enough to provide the evidence to support either claim. Of the remaining 38% of the teachers' responses, 20% highlighted the importance of the child being autonomous when sparking an interest in science, whilst 18% of the teachers' descriptions focused on their own creative teaching practices, i.e. the teachers ignited their children's interest by initiating the activity themselves. This is fascinating, because it was expected that the written descriptions would, in the main, be teacher-orientated because of the wording of the original question perhaps this could infer some recognition, by the teachers, that the pupils need to spark their own interest to be curious enough to learn science (Schmitt and Lahroodi, 2008). This notion, it could be argued, is supported when the most dominant way to ignite interest in science, as summarised in table 6.5, was found to be *encouraging autonomy*. It is also notable that this is one of the most prominent of Oliver's categories associated with responses from questions 9 and 10 (see tables 6.3 and 6.4).

It is suggested that being independent whilst investigating scientific phenomena could also enable the children to see something from another perspective, i.e. by *seeing things differently*. Perhaps this is why this category is also frequently associated with the teachers' reports of how to catalyse a child's interest in science (see table 6.5), it was also commonly associated with the responses to questions 8 and 9. The sixty-sixth response, from question 11, describes a moment where this alternative way of looking at scientific phenomenon occurred.

> Response 66: 'Discovering things for themselves, especially when they have made assumptions about the results and are totally surprised'.

This answer refers to the instant when a child independently realises that their previous idea(s) no longer fits within their world perspective. The other predominant way the teachers reported they ignited the children's interest was through *making the ordinary fascinating*. This category has also been consistently acknowledged as a predominant way to make science teaching creative during my analysis of questions 8-11 (see tables 6.2-6.5). The forty-eighth response to question 11 illustrates this category aptly.

> Response 48: 'The open ended investigations, child-led investigations, linking to real life and using our school environment to carry out lessons not just indoors but in all areas of the school'.

In this one response, the teacher has not only indicated that the children are making their own decisions to explore scientific phenomenon (i.e. they are *encouraging autonomy*), they are also reportedly utilising the everyday environment of the school (indoors and outdoors) to pique their interest (i.e. they are *making the ordinary fascinating*). It is also possible to consider that through this child-led activity *the predictable could be turned into something better* by not following a prescribed plan.

Thus far the responses from the seven likert-scale questions and four of the five open questions have been reported. There appears to be common ways to make science teaching creative, as interpreted through the teachers' written accounts of creativity; these, along with the findings from the closed questions are reflected upon in the following section.

<u>6.2.1.2.5 Summarising the examination of the teachers' self-reported views of creativity</u>

It is interesting to note that 90% of teachers claimed to be frequently supporting the children to ask their own questions (table 6.1) and yet Oliver's category *valuing questions* was regularly one of the least commonly coded categories demonstrated in their responses. I am not claiming that the teachers participating in this survey do not use questioning as a tool to develop creativity, but just that their answers to question 8-11, as I have interpreted them, do not support this initial claim. Contrary to this finding 77% of teachers claimed to be frequently supporting children to think independently, and this was reinforced by the teachers written accounts through Oliver's category of *encouraging autonomy* (see tables 6.2-6.5). This way of making science teaching creative is discussed in more detail below, along with a brief summary of the results obtained from my interpretive analysis of the teachers' self-reported episodes of creativity.

The teachers' written descriptions of creativity in the science classroom provided ample examples of these multifaceted creative episodes, many of which can be found in the appendix (6.B-6.E). The four most prevalent of Oliver's ten ways to make science creative (as summarised through tables 6.2-6.5) delivered a platform from which to understand what the teacher was doing to support the development of creativity in their science lesson(s). These prevailing categories were: *making the ordinary fascinating, modelling explanations, seeing differently* and *encouraging autonomy.* Additionally, whilst the creative undertakings allegedly encouraged independent thinking through everyday experiences I was unable to discern how much autonomy the children were given or how the varying different perspectives of the 30 plus students were catered for. It is here that I acknowledge that the questions asked in the survey itself did not specifically ask for this level of detail and as such I recognise that this is a limitation of the data collection tool and not the teachers' written accounts of creativity.

It was also interesting to note that the majority of the written accounts could neither be associated with teacher nor child-initiated creativity, that is, they were considered to be a CCA. This finding could mean three things:

1) The teachers did not make a clear distinction between TC and T4C;
2) Teachers could instinctively recognise the mutuality and compatibility between the two approaches and saw the development of creativity as a balanced duality between them or
3) It did not occur to them to provide this level of descriptive detail in their responses (this being a possible limitation of the questions asked in the survey itself).

To temper the restrictions of the survey and to garner fuller richer detail I will, in chapter 10, consider my findings whilst contemplating observed science lessons (cases A-C) because, like Johnston, I wanted to uncover whether the outcomes of the survey would be consistent with classroom practice. However, a direct extrapolation and cross-case analysis could not directly take place (Thomas, 2009) due to the observed teachers not completing the on-line survey. Thus any similarities and/or differences would be considered speculative. However, post-observational interviews took place and the three observed teachers were invited to answer questions that were triangulated with those of the survey (see appendix 5.K). The findings, from the interviews, will be contrasted with the results of this chapter later on in this thesis (chapter 9).

Whilst considering the findings from questions 1-11 it was acknowledged that there are many other issues and problems when integrating creativity into the science classroom (from the teacher's perspective). Thus the teachers were also invited to answer the following questions: '*What things make being creative in the science classroom difficult?' and 'Why do they [the teacher] think children might find it difficult to be creative in a science lesson?'.* These are questions 12 and 13 respectively.

6.2.1.3 Reports, from teachers, of why it is difficult to be creative in science lessons

Of the 101 teachers who responded to the survey, 97 practitioners answered question 12. These written accounts were placed into themes to elucidate why teachers believed being creative was difficult during a science lesson. The analytical approach taken to categorise the teachers' descriptions is outlined further in the methodology chapter, see 5.6.1.6.2.3. Figure 6.2 below offers the resulting histogram (with the categories that emerged from the teachers' responses on the x-axis). Appendix 6.F provides teacher descriptions from each of the themes.

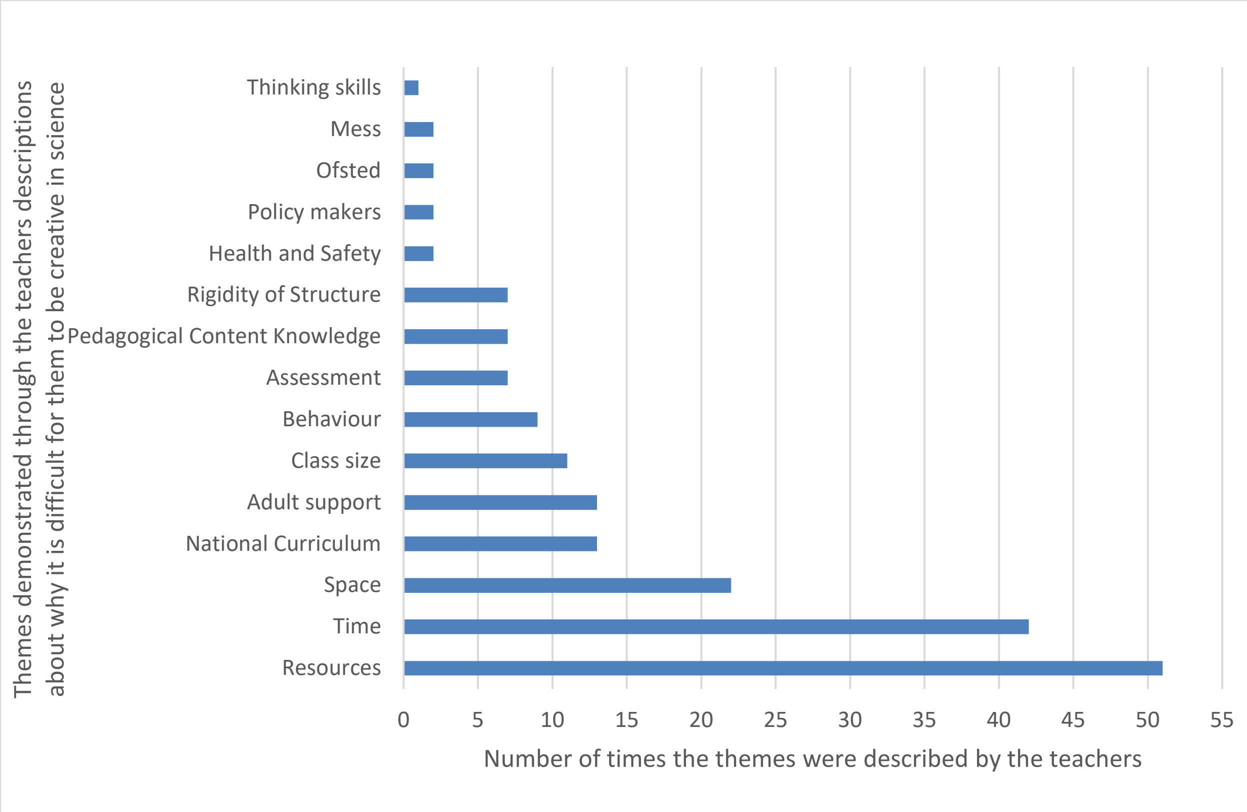


Figure 6. 2: Graph illustrating why teachers find it difficult to be creative in a science lesson

Interestingly it was resources (n=51) and time (n=42) which were the main reasons why teachers thought it was difficult to be creative during a science lesson. One teacher recounted: *'…school resources are not great and I often have to buy the resources with my own money'.* Another stated that *'...in my opinion, we are short on time for science and so we spend the little time we have cramming 'knowledge' in rather than exploring science more creatively*'.

Space (n=22) was also highlighted as an issue. A practitioner has aptly stated her frustration here: *'I would love to teach groups of about 12 in a lovely creative space, not a desk-ridden room! Never will happen!!'*. This last extract also emphasised class size (n=11) as a restriction when trying to develop creativity in the confines of the science lesson. Note the exclamation mark(s) indicating this teacher's strong feelings.

These responses however, were the teachers' pragmatic perspectives of why it is difficult to be creative in a science classroom, I also wanted to attempt to discover more about the issues and problems of developing the children's subjective creativity, so the following question was asked: *'Why do [they, the teacher] think children might find it difficult to be creative in a science lesson?'.* The following section reports the teacher responses.

6.2.1.4 Teachers describing why it is difficult for a child to be creative during science lessons

To examine the responses from question 13 the same analytical approach, as described in question 12, was adopted. This time 95 teachers completed this question. There were four who opted not to respond and two simply wrote *'see above'*, referring to their answers to question 12. These two teachers' responses were not examined because in the previous question the teachers' expressed their views about why they found it difficult to be creative, and here they were meant to reveal why they felt it would be difficult for their pupils. Figure 6.3 below provides the results of the analysis and appendices 6.G provides excerpts from each themed category.

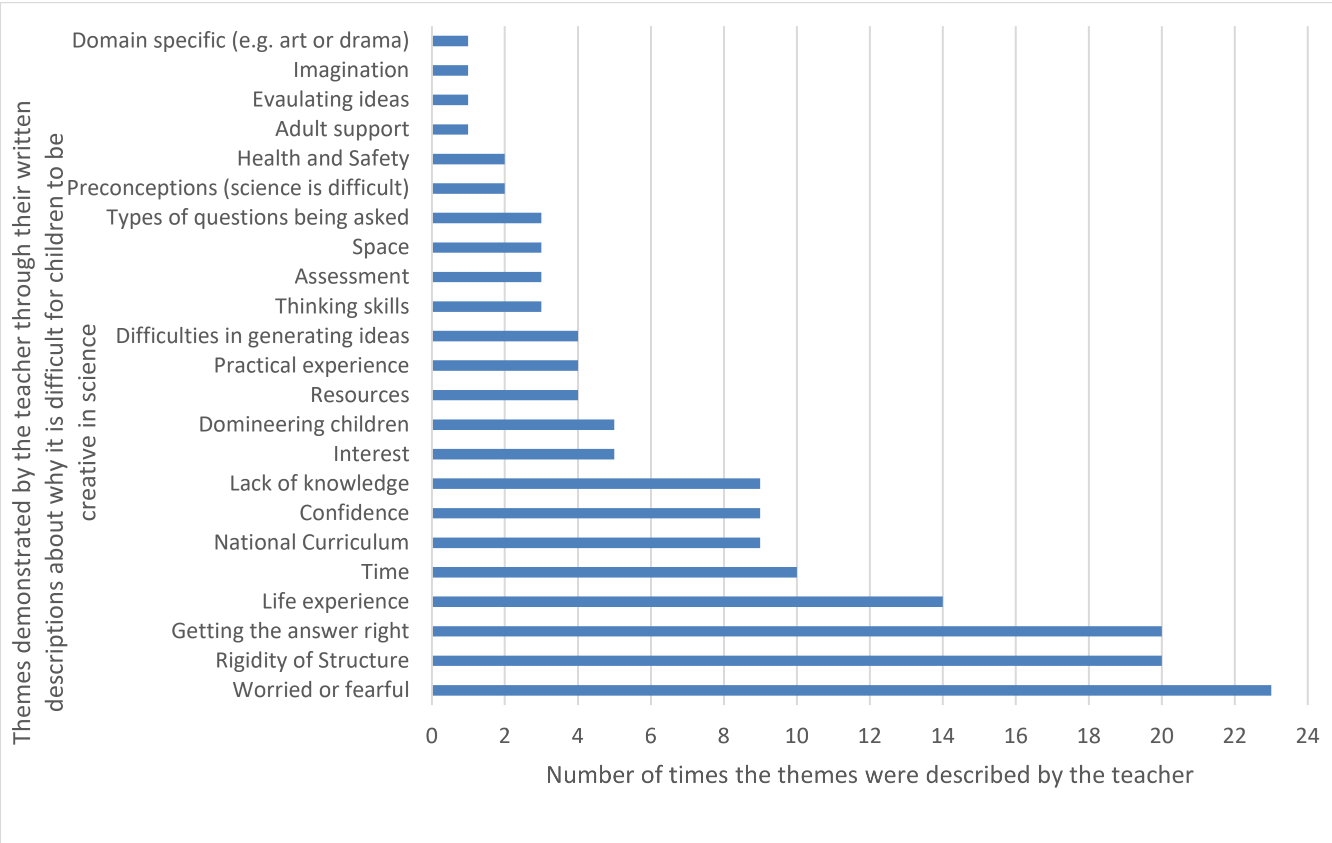


Figure 6. 3: Practitioner reflections suggesting why children find it difficult or challenging to be creative in science

Teachers appeared to believe that the children were fearful of getting answers wrong (n=23), perhaps because they believed there was a definitive *'correct'* answer (n=20). This was emphasised on a number of occasions, one example stated: *'[t]he children do not always feel that they can be creative,…they must be correct and are afraid to be wrong'*. Twenty teachers also felt that this was due to prescriptive science lessons (n=20). For example: *'Science can be seen as quite prescriptive in relation to working scientifically so teachers* *may feel that they need to direct and guide every stage instead of letting the children take ownership of their learning'*.

Following on from the above section, I also enquired about how teachers provided opportunities to formatively assess creativity during science lessons, this responded to RQ3. The results of this endeavour can be found in the following section.

6.2.2 Exploring how teachers formatively assess learning and/or creativity during science lessons (i.e. examining responses from section C of the survey)

The following section examines how teachers perceived and described the ways in which they formatively assess learning and then considers their responses to how they believe they could best assess creative ability through these strategies. I first consider the responses received from question 14 which was: *'Which aspects of students' thinking are not measured via summative science assessment tests?'.*

6.2.2.1 Aspects of students' thinking that teachers believe were not measured through Summative Tests

To analyse the 85 responses collected to question 14 the same analytical approach employed to examine the teachers' answers to questions 12 and 13 was adopted. The results can be found represented in the histogram (figure 6.4) below. Appendices 6.H provides teacher responses from the original 21 themes.

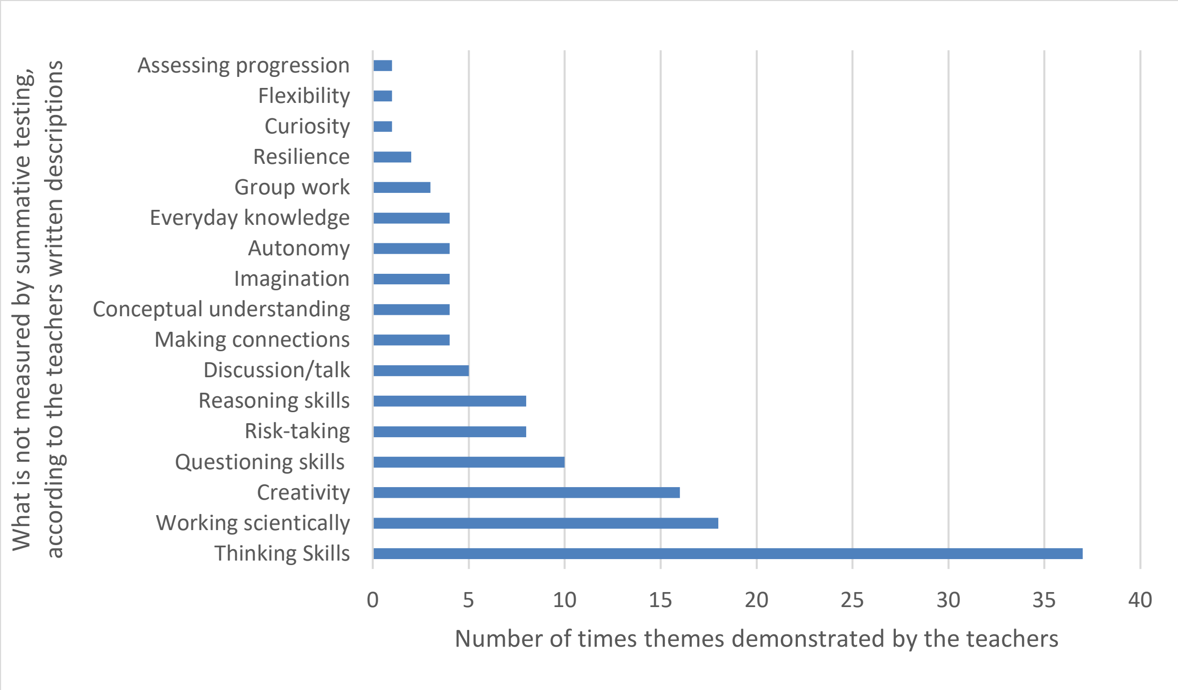


Figure 6. 4: A graph to indicate the frequency of teacher's descriptions highlighting what is 'not' measured via summative testing

The most dominant theme which emerged was thinking skills (n=37); within this category the teachers considered how summative testing could miss the way in which pupils develop their ideas and how this could elucidate more than just the 'correct explanation', for example:

> Response 74: '...[a] girl who noticed what happened when she changed the number of bulbs and how she wired them into a circuit, her practical/kinaesthetic approach led her to notice things which some of the academically "more able" failed to notice'.

This pupil has presumably observed a difference in the brightness of the bulbs, when differently configured in the circuit. Hence she was developing her understanding in a way that some of the 'more able' reportedly had missed.

Another teacher stated that this more formal way of testing *'...ask for specific answers and children are often taught to respond appropriately'*. Thus, it may not be surprising that working scientifically such as *'…questioning, creating experiments, choosing the correct equipment, researching, presenting findings'* was found to be the second most prevalent theme that could not be adequately assessed through this written format (n=18).

Creativity was mentioned by 16 teachers (n=16), but all these references were directly related to the abstract noun itself, and not their understandings of the term, and how it relates to assessment tests. For example one teacher stated, '*Summative tests usually concentrate on the knowledge learnt or retained not the amount of creativity used'*. The referral to expending a specific quantity of creativity may also infer that the teacher possibly comprehends creative thinking as a quantifiable unit of measurement (although they do recognise that it cannot be measured using summative means). This way of looking at creativity (if indeed the teacher sees it in this manner) is in contradiction to the fluid dynamic entity that I have envisaged it to be when in the classroom environment (see literature review, section 2.2-A.3 and section E).

Having highlighted that many of the teachers believed that formal science tests do not reveal the child's thinking skills, practical aptitude and creativity, I wondered how these teachers could go about assessing these aspects of learning. The questions I invited them to answer were:

15) Can you describe the range of different strategies you use currently to assess your children's on-going progress in science learning (i.e. tests, tasks or assessment strategies)?
16) Which of the assessment strategies described in Q15 most closely assess creative ability in science? and
17) Why does the assessment strategy discussed in Q16, in your opinion, more readily assess creative ability?

Of the 101 submitted surveys, 96 teachers completed question 15, 94 answered question 16 and 82 responded to question 17. The actual method of examining the responses from these three questions is described in greater depth in the methodology chapter (section 5.6.1.6.3.2).

The teachers' responses to these three questions have the potential to illuminate descriptions of assessment-in-practice and suggest when there were opportunities to assess creativity-in-learning, thereby answering RQ3 (see methodology, section 5.4). To begin to answer this RQ I attempted to associate each the teacher's written accounts to question 15 with one or more of Wiliam's (2011) five key strategies of formative assessment. These are:

1. 'Clarifying, sharing and understanding learning intentions and criteria for success
2. Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning.
3. Providing feedback that moves learning forward.

4. Activating learners as instructional resources for one another.
5. Activating learners as the owners of their own learning.'

(*ibid*:46)

See chapter 3.1-D.2 for a fuller description of each, and section 5.6.1.6.3.2, of the methodology to understand how the responses from question 15 were examined. It was intended that this analytical approach would look at the nature of the reported formative assessment techniques currently being employed by the teachers in their science lessons.

6.2.2.2 Applying Wiliam's (2011) five key strategies as a means to understand the nature of formative assessment in the science classroom

The results of examining the responses from question 15 can be found in figure 6.5 below.

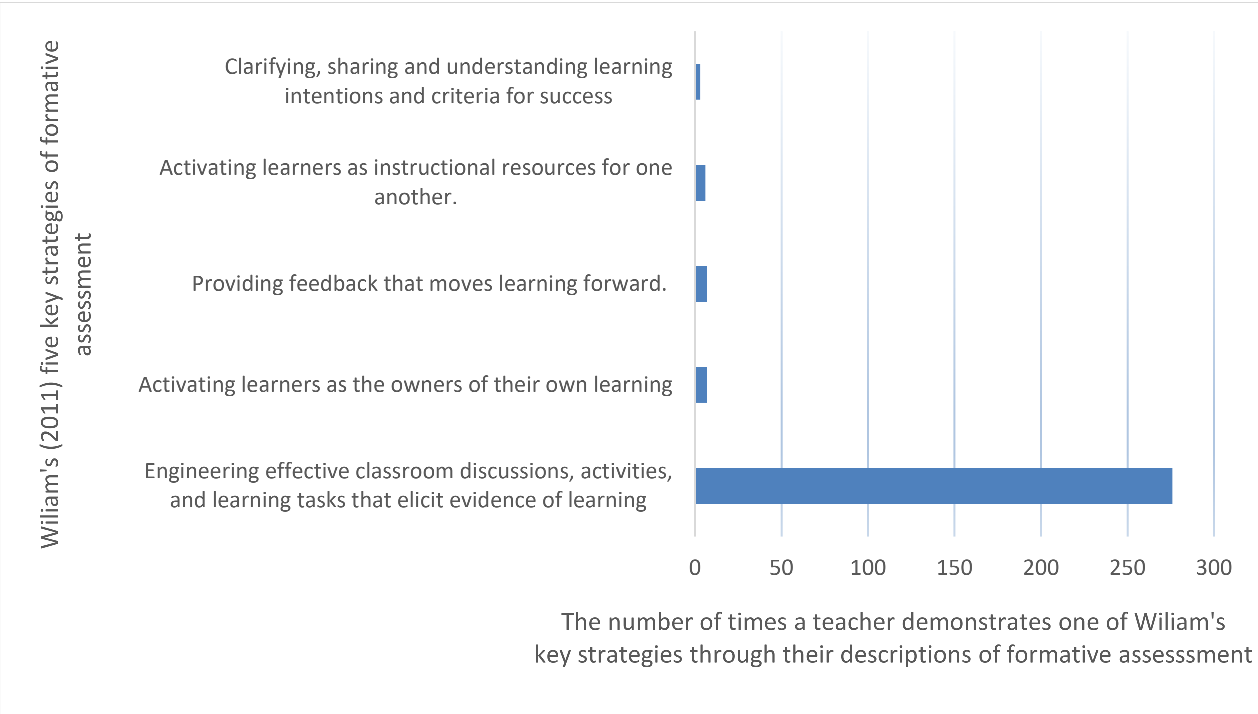


Figure 6. 5: Graph illustrating teachers' self-reported implementation of formative assessment in the science classroom (through Wiliam's five key strategies)

The nature of question 15 invited the teachers' to describe the range of strategies they employed when they assessed their pupils' learning in science. This meant that each of the 96 teachers, who answered this question, went on to describe the multiple techniques they made use of to elucidate evidence of learning. Thus, there is a substantially large number of coded themes relating to Wiliam's second key strategy, i.e. *effective in engineering discussions, activities and tasks that can elicit evidence of learning* (n=276).

Figure 6.5 quantifies the number of ways in which the teachers formatively supported and assessed their students. However, I wanted to clarify what the techniques actually were, that elicited this evidence of learning, thus the strategies cited by the teachers were tallied and the resulting histogram (figure 6.6) was generated.

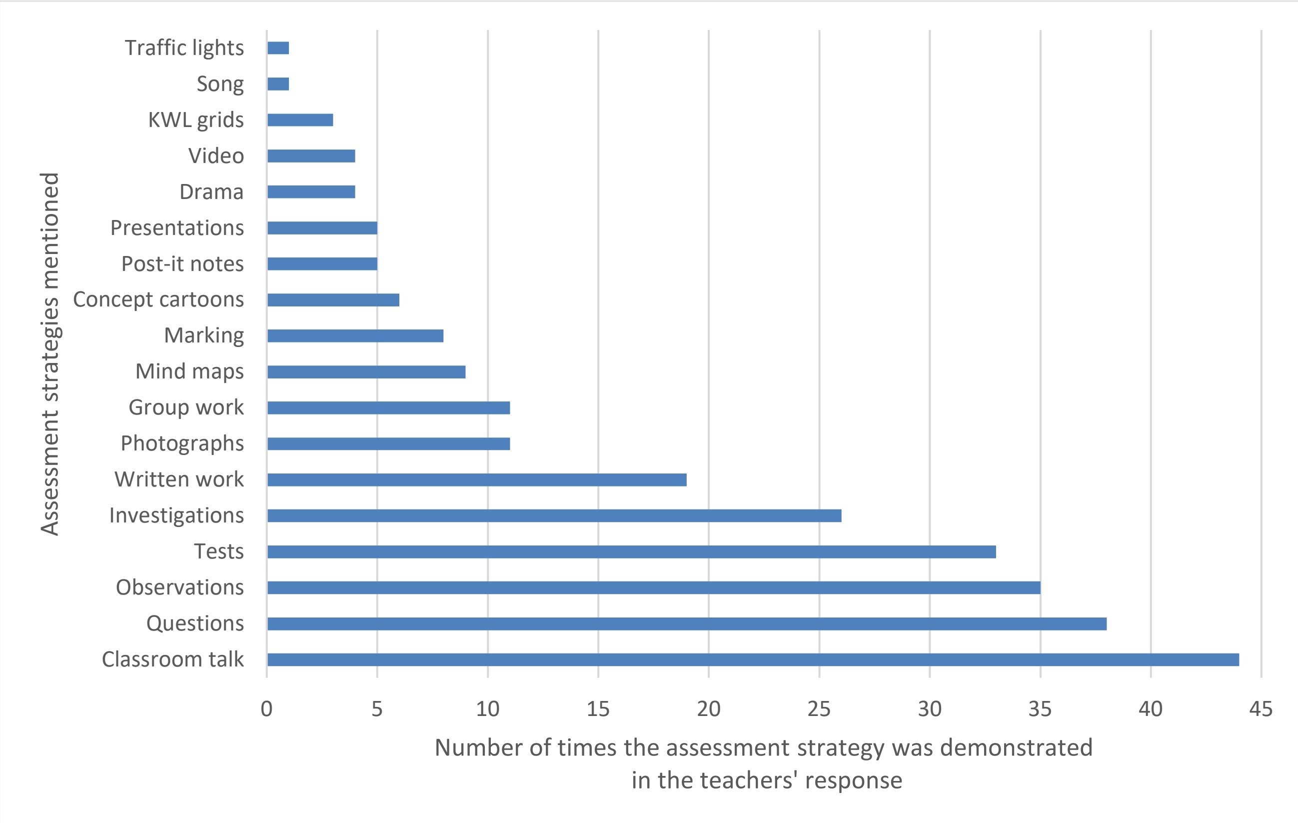


Figure 6. 6: Formative assessment strategies that are perceived as more readily able to assess creativity

Interestingly formal tests were still being employed, as a means to formatively gauge children's learning (n=33). This, Eady (2008) suggests, is not necessarily a bad thing, if used in conjunction with other methods. Perhaps this is why classroom talk (n=44), questioning (n=38) and observations (n=35) were also reportedly being employed by the majority of teachers. These latter three methods of formative assessment were also depicted as being the preferred, present day means, of formative assessment in science through Earle's (2014) study of PSQM data (a study originally described in the literature review, section 3.1-C.3).

I have to acknowledge here that, similarly to Earle's (2014) study, the diverse responses proffered by the teachers (i.e. the descriptions of the assessment strategies employed by the teachers) did not managed to successfully capture the rich data necessary to lay claim to fulfil a formative purpose. This fulfilment of formative purpose, Black and Wiliam (1999) suggested, occurs when '…the evidence is actually used to adapt the teaching to meet the needs [of the learner]' (*ibid:*2). I believe that specific examples/evidence of children's developing learning was not described by the teacher because the question itself did not invite the teacher to divulge this kind of information.

Nevertheless, I still wanted to understand which of the formative assessment strategies mentioned in question 15 was perceived as more readily able to assess creative ability. Question 16 specifically addressed this consideration by asking the teachers to pick the assessment technique they believed could capture this phenomenon. The resulting histogram was produced to display their answers (see figure 6.7 below).

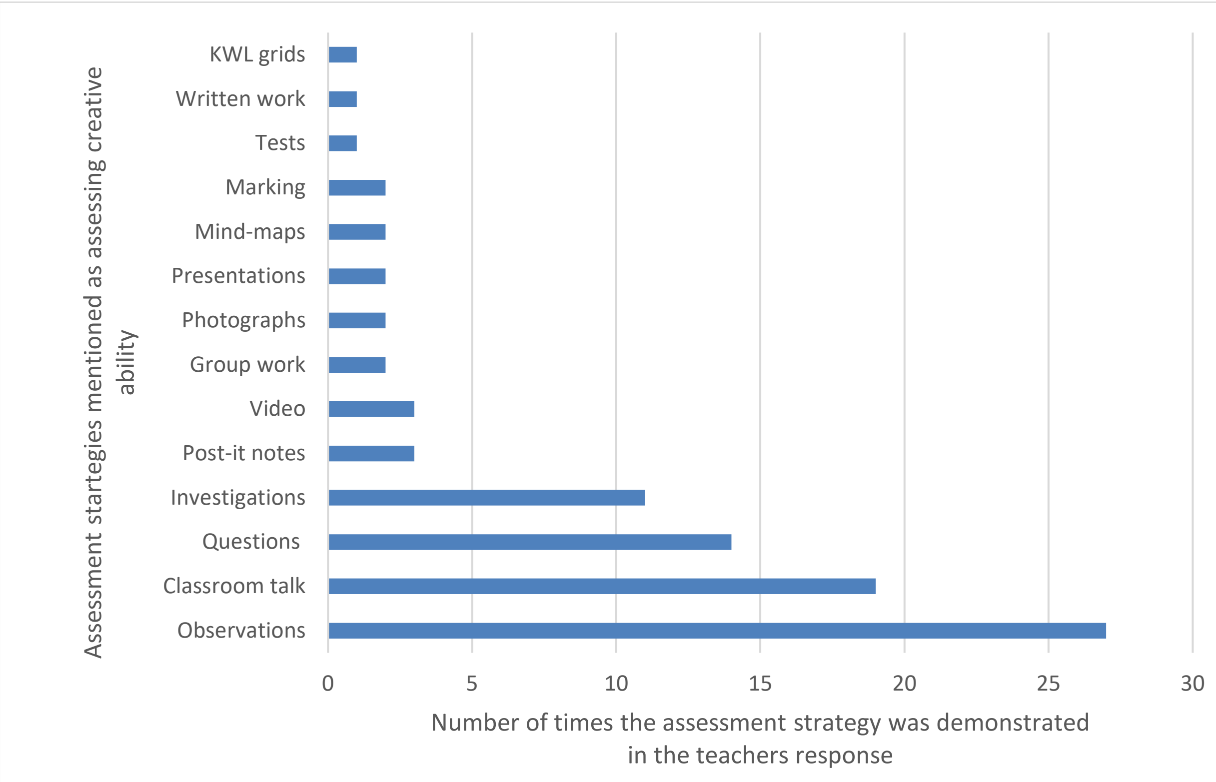


Figure 6. 7: Formative assessment strategies which teachers report as having the most potential to assess creative ability.

Figure 6.7 illustrates that observations (n=27), classroom talk (n=19) and questioning (n=14) were, yet again, considered, by the teachers, to be formative assessment techniques of choice when assessing creativity (akin to the findings from responses to question 15). Fascinatingly, only one teacher mentioned employing tests when assessing creative ability. If these results were compared to the summarised findings from question 14 (see figure 6.4) then it could be suggested that all but one of the teachers believed that formalised tests may not measure creativity.

Following on from question 16 the next question asked for a justification as to why the chosen assessment strategies may assess creative thinking. It was intended that this would enable me to understand how the teacher could adapt the technique to capture the iterative process that is creativity-in-learning (as described in chapter 4, section E). It was interesting to discover that 33 teachers described how observations, talk and questioning appeared to illuminate thinking skills. An example of this includes a teacher referring to an observation of her pupils, during an investigation; she stated that, *'The children are practically trying out their ideas. If something doesn't work they retry and think again to find a solution'*. Here the teacher is talking about the learners demonstrating mini-c creativity (Beghetto and Kaufman: 2007), because they are trying to understand/solve their current predicament on an intrapersonal level. However, it could be claimed that the social interpersonal aspects of learning (i.e. the little-c as defined in the literature review, section 4.1-E.1 - E.4) are being neglected. A response which infers this interactive teacher-child social exchange reportedly occurred whilst a teacher observed and questioned her pupils', with the stated result of these assessment strategies being *'You can see how a child works and ask them to explain and clarify their thoughts'.* It is suggested that the outward expression, post cueing from the teacher, when the children clarify their subjective thoughts could represent the articulation of interpersonal little-c. However, how this goes on to reify the iterative, dynamic process of creativity-in-learning, as defined through my proposed model (see figure 4.1), I cannot be sure. This lack of detail, I feel, only serves to highlight the limitations of any written response to a survey.

Whilst the above example demonstrates an endeavour between teacher and child to enable the learner to express their thinking, it would also be interesting to consider who the agentive owner of the assessment strategies are, because at present it is not known whether the preferred assessment strategies were viewed by the teacher as a strategy by which to facilitate creativity for the child (i.e. teacher-focused), or if the teacher saw it as a means for the child to assess themselves (it is child-focused). The responses from question 17 were individually analysed to find out who, through the teachers' written accounts, was reportedly initiating these strategies. When I was unable to clarify who was applying the assessment strategy they were coded as being a formative assessment strategy (FAS). See section 5.6.1.6.3.2 of the methodology chapter for a fuller explanation of the analytical method employed. The results are presented in table 6.7 below. Appendix 6.J provides excerpts from the survey that demonstrate each of these three categories.

Reported formative strategies from question 17 are…	No. of themes	%
FAS	31	**38**
Teacher-focused	14	**17**
Child-focused	37	**45**

Table 6. 6: Considering who is employing the formative assessment strategies, as reported by the teachers' descriptions when responding to question 17

It can be inferred, from the summarised data in table 6.7, that when it comes to developing creativity through formative assessment techniques the teachers reported that the pupils were, for the majority of times, leading the strategies. This however, does not mean that the teacher is enabling the child to be an autonomous learner, just that the teacher reflectively described the child as applying or initiating the assessment strategy themselves.

6.2.3 Formative assessment: the next steps towards reifying creativity-in-learning

Thus far the teachers' descriptions of formative assessment-in-practice have not provided enough rich description to conclude how they successfully met the formative learning needs of the pupils, nor is there enough detail in the teachers' responses to indicate that they were, in actuality, able to elucidate creativity-in-learning, although there is an indication that social exchanges could augment this practice. Perhaps, I suggest, what we need to do is acknowledge 'the spirit of AfL'. How these forms of interactions could be illuminated (through the examination of data transcribed, from observations) is described in the methodology chapter, section 5.6.2.6, and this could respond to RQ4. The findings from the subsequent analysis of three cases (A-C), which were fully transcribed post observation, can be found in chapter 8 of this thesis.

6.3 End of chapter summary

The teachers' self-reported promotion of creativity in primary school science, as depicted through their responses to the survey questions, were described as taking place through numerous and diverse creative activities; these descriptions of the science lessons were interpreted through a framework adapted from Ann Oliver's ten ways to make science teaching creative. Through this examination the activities were construed as being designed to capitalise on everyday phenomenon, so that the students could be provided with the opportunity to independently discern (or make connections to) the scientific, perhaps from alternative (even unexpected) perspectives. However, how the children's subjective and on-going development of creativity is being (or was) formatively illuminated was not adequately demonstrated or explained through the teachers' written accounts. This is not the fault of the teachers' attempts to answer the survey's questions but a possible limitation of the level of detail requested via the research tool itself.

Subsequent observations and post-observational interviews will be contrasted with the survey's findings (these can be found in later chapters of this thesis) to further validate and distinguish the extent to which teachers believed they were (and were objectively observed to) promote creativity in their science lessons. This, it is hoped, will also capture how creativity-in-learning can be (and potentially is being) naturalistically arising in lessons.

Chapter 7

Inferring, from three contrasting cases, illustrations of teachers' practices

7.1 Aims of illuminating distinctive features of teaching practices

It was intended that the observations of primary school science lessons would enable me to critique pedagogical enactments, to illuminate where and how creativity was evident. To reveal these distinctive features of the teachers' practice, which support and nurture creative thinking, I undertook a hermeneutic approach (Alvesson and Skoldberg, 2009) when observing eight very different science lessons. Having reflexively considered these eight observations I chose to focus on contrasting three related cases, for they aptly reflected three teaching approaches, i.e. expositional, 'teaching creatively' (TC) and 'teaching for creativity' (T4C), as described in the literature review (section 2.2-B.3). Further reasoning behind the selection of these three cases can be found within the methodology chapter (section 5.6.2.1).

In the methodology chapter (section 5.5) I also referred to research by Johnston (2007). It was Johnston's study which indicated that there was little correlation between the teachers' espoused views of their practices and what was, in actuality, happening. However, Johnston's study only included pre-service teachers, I suggest that the findings could potentially be true of longer serving practitioners, and such an example can be found below.

A teacher, who had been in-service for over a decade, was so enthusiastic about my research that following a conversation I was invited into her classroom and introduced to her class of thirty year 1 pupils. Preceding this introduction the teacher explained to me that she was always learning - learning not just for herself but for the pupils too. She confidently stated that: *'I'm here for them [the children], you know!'*, she continued, *'I always put them first in my mind. I learn so that they can learn and visa verse'*. I was impressed by this teacher's motivation and was intrigued to observe what she described as mutualistic learning environment. Like Johnston's study, what happened next made me reflect upon how far a teacher's self-reports may or may not accurately indicate what they, in reality, do.

During my observation of the science lesson, the in-service teacher introduced the children to a mouse (a cuddly toy) and told them that he was having a terrible time sleeping at night because of the lights outside. She went on to read a letter (supposedly) from the small rodent asking the children to invent a good pair of curtains to keep the light out, so he could sleep better. She explained that to find out what made a good set of curtains the children would need to perform a fair test. To this end the teacher demonstrated (in front of the whole class) how to place the torch

10cms away from a cardboard window which had the single variable (the curtain material) attached. She then went on to explain how to fill in a pre-designed printed results table. The teacher held up the print out and carefully clarified to the children that all they had to do was provide a list of the types of materials used (cotton, plastic, paper etc…) and then classify them as either opaque, transparent, translucent etc… and then following this describe how much light got through the proposed curtain material (a lot, some, none). The pupils were placed into groups of three, supposedly to allow them to exchange ideas and collectively form a group opinion about the best curtain material. Each group was handed a similar tray full of apparatus for the experiment which contained: a cardboard cutout window, a torch, a ruler, five types of materials for the curtains (black cloth, kitchen roll, tracing paper, a clear plastic sheet and writing paper) and the printed-out worksheet to complete.

What followed was an hour-and-a-half of the teacher and TA tirelessly supporting the children; they ensured the pupils all had the appropriate equipment and followed the teacher's directions (as they were set out during the introduction). I had to admire the adults' work ethos, as they scampered about making sure all but one variable (the curtain material) was controlled to ensure a fair test; they achieved this by 'handling' and 'moving' the equipment to where it reportedly needed to be, on behalf of the children. What I witnessed was an activity that appeared to pique the children's interest (e.g. the letter from an insomniac mouse) but this way of working scientifically did not readily offer opportunities for the children to devise their own version of a fair test. This was one of the first science lessons I witnessed that helped me realise that teachers' self-reports of their practice can be rough approximations of their pedagogy, and the children's learning. As an interpretivist, seeking a more comprehensive world view of the teacher's practice another method (e.g. none-participant observation) could be triangulated with the teachers self-reported views of their creative practice, such as those described and examined in chapter 6 (Denzin and Lincoln, 1994).

Having questioned over 100 in-service teachers, and examined their self-reported examples of creativity in their science lessons (see chapter 6), I would have liked, just as Johnston did, to consider whether my findings (as an observer) corroborated their views of their classroom practices. However the three teachers observed (cases A-C) did not complete the survey, despite various promptings, so a direct extrapolation and cross-case analysis could not take place (Thomas, 2009) and any similarities and/or differences are somewhat speculative. Therefore, in order to delve deeper I undertook post-observational interviews with all three of these teachers, and the questions were triangulated with those of the survey (see chapter 9). The findings, from the interviews, will be contrasted with the results of the observations, in chapter 9, to explore how far practice reflected reported teacher values.

7.2 Case descriptions

To provide context to these three observations (cases A-C), so that the reader can better comprehend what is taking place during the science lessons, I have provided brief descriptions of each below.

7.2.1 Case A: 'a history of light'

The first science lesson was originally described to me, by professional peers, as a creative, end-of-topic, interactive session, which was reportedly so good that it had been delivered to year 2, every year, for the past eight years. The lesson consisted of the teacher handling and demonstrating a variety of unusual objects to pique the children's interest, whilst tales were recounted about historical figures who had used them whilst alive. This strategy of associating story-telling with science is not new, it has been adopted and applied to primary science lessons by many, including: McCullagh *et al* (2010), Turner and Bage (2006) and Feasey (2005). Turner and Bage (2006:92) claimed that some may consider this approach not to be 'real science' but McCallagh *et al* (2010:23) tempered this by stating that it is 'relevant and accessible' and captures the children's imagination and interest in science (Turner and Bage, 2006). McCullagh *et al* (2010) goes on to state that it puts a child at ease and if effectively employed, in conjunction with other creative teaching approaches, it could stimulate: child-led dialogue, the generation of ideas (ibid), questioning skills and problem solving (Turner and Bage, 2006); thus providing opportunities for the pupils to become the active agents of their own learning (McGregor, 2007).

7.2.2 Case B: 'dramatic science – Marianne North'

This second science lesson was based around the topic of the rainforest. This lesson consisted of an approach which incorporated a number of McGregor and Precious'-(2015) dramatic strategies. These are the sorts of activities that Glăveanu (2011:127) suggested would involve 'interactions with the physical and social world' and, according to Glauert and Manches (2013), if these actions were allowed to play out the children would reportedly be motivated to express their subjective thinking through their natural dialogue and body language.

7.2.3 Case C: 'bright ideas time – life processes'

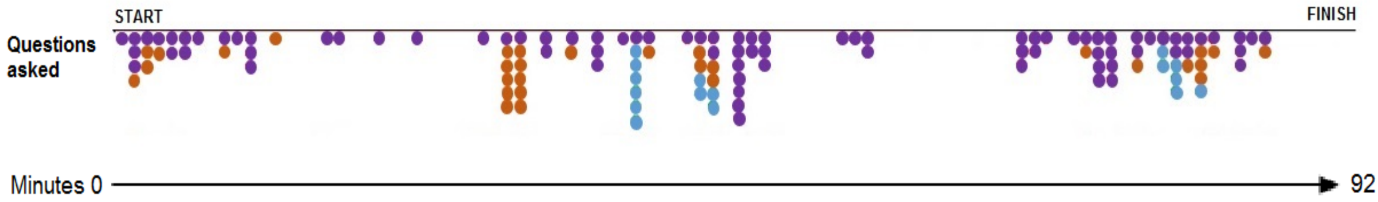
The third science lesson was centered on life processes (human and plant). It consisted of strategies which incorporated the 'Bright Ideas Time' module, which can be found at http://www.pstt.org.uk/resources/continuing-professional-development/bright-ideas-in-primary-science.aspx. The activities, found on the above website, reportedly allow the learners to be actively involved in their own cognitive processes through 'higher order thinking' (Hanley *et al*, 2015). These cognitive attributes were originally described by Bloom *et al* in 1956, and are linked to *'Bloom's Taxonomy of the cognitive Domain'* (Collins, 2014). This taxonomy consists of a hierarchy of six levels. They are: knowledge, comprehension, application, analysis, synthesis and evaluation. It is the latter three of these six which are thought to promote higher forms of thinking skills (*ibid*). Hanley *et al* (2015) reports that these abilities can be developed through the children via teachers who have received relevant CPD training. This particular teacher had, the previous year, undertaken such training.

Whilst all three cases were very different, I had, in the methodology (section 5.6.2.2), indicated that generalisable features of the teachers' practices, that support creativity could be illuminated through them (Mitchell, 2006). By highlighting these characteristics I would be responding to RQ2. I began answering this RQ by deliberating upon the nature of creative teaching and its composite practices (TC and T4C). Further detail surrounding these two composite teaching practices can be found in the literature review (section 2.2-B.3.1). In brief, TC encapsulates how the teacher communicates about science in an imaginative and innovative way and T4C relates to teaching that encourages and nurtures learners to develop and express their own creativity (Davies, 2011). However, teachers need to *deliver* the statutory requirements that demand children *know* factual scientific concepts listed in the National Curriculum (NC) prescribed by the DfE (2013b). With this in mind and at some point they will need to consider that the children have learnt the science as set out by the NC. This could be achieved, according to McGregor (2007), by learners reciting correct, repeatable answers, and with this in mind I have also considered expositional teaching (see literature review 2.2-B.3.1).

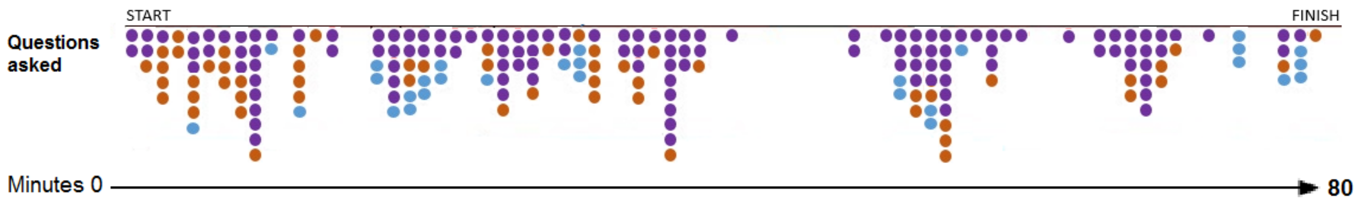
My anthropological attempts to elucidate these distinctive features began by analysing all of case A's teacher-led questions (this is previously described in the methodology, section 5.6.2.3). The questions were analysed in this manner because it was believed that the nature of the questions (e.g. be they open, pseudo-open or closed, for example) could be indicative of aspects of TC or T4C. This analysis of teacher-initiated questioning would also seem a sensible place to start this chapter. However, instead of just examining case A's questions, as I did in the methodology, I will examine the questioning techniques of all three of the teachers observed.

7.3 Examining the types of questions asked by the teachers in cases A-C

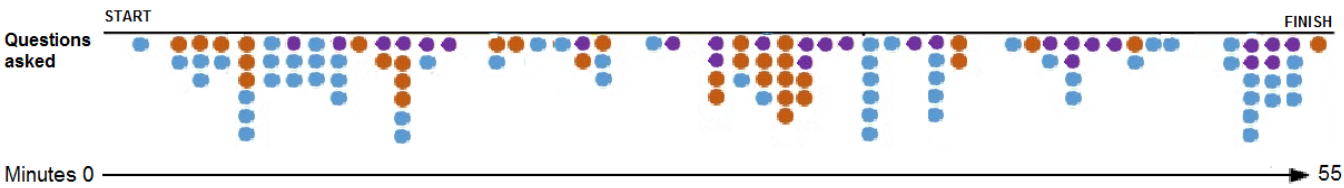
The teachers' questions were interpreted through a revised version of Wragg and Brown's (2001) and Brown and Edmondson's (1984) taxonomy of questions (this is described in more depth in the methodology chapter, section 5.6.2.3, and a summarised version can be found in appendix 5.G). From this I produced a question frequency timeline to illustrate the open, pseudo-open and closed questions asked per minute in each case. The types of questions asked per minute are represented as strings of coloured dots from start to finish of the lesson, i.e. blue, brown and purple dots respectively (see figures 7.1a-c). Case A's question frequency per minute can also be found in the methodology chapter (figure 5.2), however I also include it below, along with case B's and case C's, for comparative purposes.



(a) Case A



(b) Case B



(c) Case C

Ref: classifying Questions:

- Open: requires a relatively wide ranging answer.
- Pseudo-open: the form of an open question is used, yet the teacher is searching for a narrow answer.
- Closed: requires a relatively brief answer

Figure 7. 1: Question frequencies per minute during three science lessons (cases A-C)

Cases A and B questions, per minute, indicate that both teachers, in the main asked closed questions. That is, the majority of these enquiries posed required answers that were brief (64% and 60% respectively). This frequency of narrow, teacher-led questioning is reported to be quite normal in most classrooms (Wood, 1992; Dillon, 1994). However, in direct contrast to both cases A and B the third teacher, in case C, asked mostly open questions (47%). This prevalence of broad questioning, which invites a wide range of responses (Wragg and Brown, 2001) is counter to Wood's and Dillon's findings.

The types of open questions asked during the activities employed by the teacher, in case C, exemplify, according to Gillies and Khan (2009), the kinds of utterances specifically tailored to promote exploratory interactions. These articulated verbal exchanges, Gillies *et al* (2014) suggested, may include 'cognitively challenging questions, where they [the children] are required to think critically about the issues and justify their responses' (*ibid*:128). That is not to say that closed questioning does not promote classroom exchange that might promote challenge, for in the literature review (section 2.2-B.1.1.2), Bird (2011) advised that all forms of talk in the classroom indicate some form of participation, and as Chin (2007) stated:

> 'Because teacher questions are a frequent component of classroom talk, they play an important role in determining the nature of discourse during science instruction. The kinds of questions that teachers ask and the way teachers ask these questions can, to some extent, influence the type of cognitive processes that students engage in as they grapple with the process of constructing scientific knowledge' (*ibid*:815-816).

To better understand the mediatory influence of teachers' questions on children's engagement I considered the actual context in which the questions were posed. Below I choose a few typical questions asked by the teachers to demonstrate why it is important to consider the social setting within which the question is articulated. Elucidating the context renders more explicit reflection upon the pedagogical approaches being adopted by the teacher i.e. whether they are being more or less expositional or, indeed, exploratory.

I began by examining some of the closed rhetorical questions asked in case B. These tended to be associated with the managerial aspects of the lesson, for example when the children were arranged on the magic carpet (i.e. a rug placed on the floor of the classroom), the teacher asked, *'Right…can you sit on the magic carpet for me?'* and *'Are you ready [to fly to your destination]?*'. Whilst these questions were being asked to ensure the smooth running of the lesson (Wragg and Brown, 2001) it cannot be claimed they were uncreative, especially when they were related to flying to a rainforest in such an imaginative way. There are a number of creative rhetorical questions asked by the teacher in case A too. For example, she invited the children to lie down on the floor and imagine they were in hospital (pretending to be wounded soldiers from the Crimean war). She did this so she could enact being Florence Nightingale and ask questions during a scripted phase of the lesson, she moved around the classroom asking the pupils, *'Has somebody written to your mother to tell her that you're getting better?'* or, *'Are you sure you had enough to eat today?'.* The context in which these closed questions were asked is certainly an apt illustration of Davies's (2011:44) description of TC.

Closed questions can also be used as a recitation tool, these questions are employed to test or stimulate recall of what was previously encountered, or to cue students to work out the answer the teacher holds in his head from clues provided in the question (Alexander, 2008). An example of recollection from an earlier demonstration comes from case A. The teacher had previously produced sparks by striking one piece of flint against another and asked the question ten minutes later, *'I've got some piece of stone, remember what the stone is called?* The children were expected to recall the flint from minutes earlier. A fuller description of this question-answer session can be found in the methodology chapter (section 5.6.2.4.2). To represent an example of cuing I refer to a question which was asked during case B. The teacher finished arranging the pupils on the magic carpet and invited the children to think about their actions in a car, she asked, *'What do you do in your car [first]?',* she went on to act out putting on a seatbelt, to place an emphasis on the expected response. It was argued by Seja and Russ (1999) that physical enactments (or fantasy play) could form an emotional understanding between the child's imagination and the desires of others. Thus, through the teacher acting out putting a seatbelt on, the watching students associated this with being in a car. That is not to say that all closed questions like these were designed to be restrictive, for the desire of the same teacher to transport the learners to an imagined rainforest, through fantasy play, was developed through these passionately engaging questions. To achieve this, whilst the pupils travelled on their magic carpet, to their destination (in this case the rainforest), the teacher asked them to imagine how they would feel by saying, *'We're going over the English Channel, over France, we're flying very fast, you might have your hair streaming behind you, you're very fast. Right. How might it feel?',* she also invited them to consider what sort of things they may have seen beneath them, *'…we're flying through the air. What can you see?',* at times the teacher was more specific about the geological areas she wanted them to consider, for example, *'What are you going to see underneath you in the Sahara?'*. Seja and Russ (1999) argue this type of emotive questioning can enable learners to interact with the imagined environment and become more engaged with the subsequent activities. After considering the above I can discern how the teacher is initiating imaginative activity and cuing the children, through her use of a travelling magic carpet (TC), so that their imaginings/ideas can be expressed, albeit somewhat briefly. Whether this is T4C is debatable, for whilst the students' express ideas, these are only fleetingly articulated and there is no evidence of further or deeper cognitive development. To illustrate the nature of this interaction further, and to demonstrate its effect on the promotion of creative thinking, I will examine the verbal exchange (i.e. when they were imagining that they were flying over the Sahara desert) in greater depth in the following chapter (section 8.3.1).

Physical modelling by the teacher (such as the enactment of placing a seatbelt on) also occurred in case C. It was employed after the teacher asked her class, '*What do I mean by respiration?'*. This perceptively more open question (that was classified as being pseudo-open) should, according to Chin (2003) provide the students with the opportunity to expose alternative conceptions, which they did, such as one child responding, *'Is it like start again?',* and another enquiring, '*Is it how to breathe?*'. Following these alternative viewpoints being articulated the teacher went on to pose a closed (recall) question. She asked, '*What are we all doing now without thinking about it?',* answers were invited whilst the teacher exaggerated breathing in, and then out (i.e. extending her chest and then deflating it), so that the pupil's response could become based upon observation (Wragg and Brown, 2001). The breathing in and out actions prompted the response, *'Breathing',* and the teacher acknowledged this as correct. Interestingly, having exposed two alternative conceptions initially, the teacher reveals an alternative notion of her own, for she appears to believe that respiration was about inspiration and expiration, and not about the release of energy at the cellular level. This is reportedly a commonly held belief of pre-service practitioners (Badj, 2010) and it also appears to be accepted as the correct scientific answer with this particular qualified teacher.

As I stated above, it was Chin (2003) who had claimed that the more open a question, something akin to '*what do I mean by….?'*, the more ideas would be proffered. I offer excerpt 7.1 (appendix 7.A), from case C, to illustrate just this phenomenon. Whilst there were 13 questions in total, within this 12 minute episode, it is the same question asked repeatedly, which was, *'How do I know I'm alive?*'. The first two occurrences were part of the initial set up and explanation of the activity itself (so they were managerial and rhetorical in their nature), but of the remaining 11 the students provided eight distinct answers, which included ideas, such as: *having/feeling a pulse* (lines 26 and 59); *changing* (lines 34-25 and 128); *senses (feeling, touching and tasting)* (lines 63-64); *breathing* (line 68); *making objects move* (line 73); *being noticed* (line 89-90); *growing* (line 75) *and finally being able to think* (line 107). This provides evidence of Chin's theory and also illuminates the children's ability to think divergently (de Bono, 1992). However, these types of diverse rejoinders, I have previously theorised, are one facet of creativity-in-learning (see literature review section 2.2-A.3.3) and when eliciting such responses I also need to consider how the teacher critically replies to these individual thoughts (i.e. how they are evaluated). Thus I am specifically interested in how the teacher assesses the children's ideas, i.e. does she facilitate further reflection or, enable them to critically re-consider their own thoughts? The teacher in case C interacts with the children's expressed thoughts in two ways: 1) she repeats the child's answer or paraphrases it (this occurred six times) or, 2) she elaborates upon them through teacher-led reflection (this happened five times). These have been highlighted as such in appendix 7.A. Whilst the teacher appears to reify her evaluative critique of the pupils' thinking it could be argued that these questions were not 'cognitively challenging', as defined by Gillies (2013:128), because the pupils' did not '…think critically about the issues and justify their [own subjective] responses', at this specific period in time. I have reflected upon this exchange further in the following chapter (section 8.4) in order to illuminate the interactions effect on the reification of the children's creative (and critical) thinking.

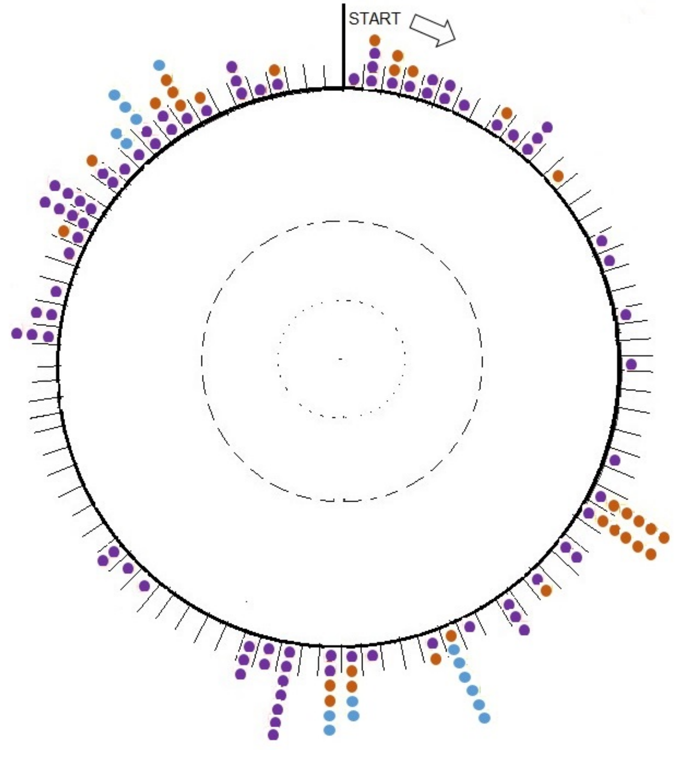
I have given consideration to the nature of some of the questioning in the three different science lessons (cases A-C) and noted that, no matter the type of question being asked (closed, pseudo-open or open) all three teachers engaged their pupils through what Seja and Russ (1999) referred to as emotive questioning. The teachers were also open to alternative ideas being expressed, thus the children felt at ease enough to offer unusual or quite alternate responses/answers.

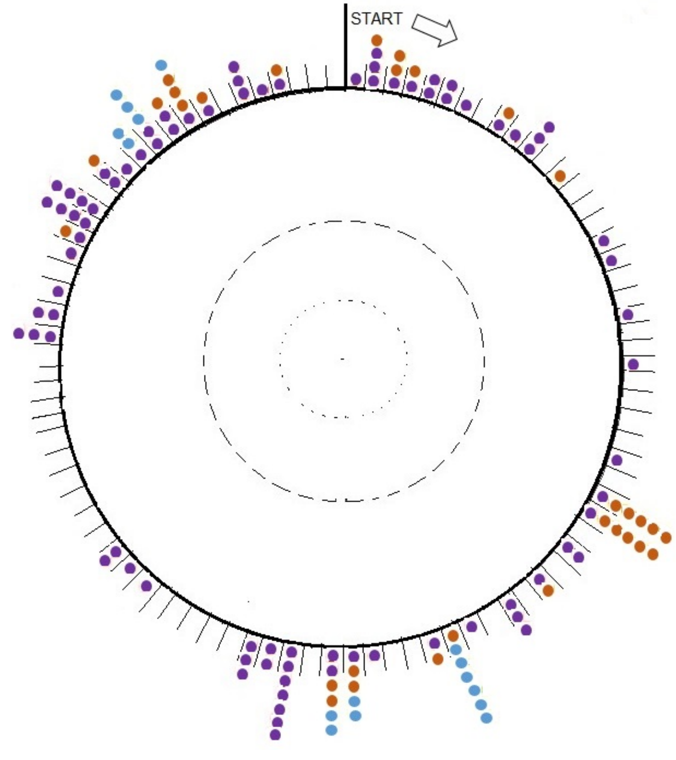
An apt example of this type of imaginative (alternative) response was previously described in the methodology chapter (see excerpt 5.1, section 5.6.2.3). Here a child expressed his views that the wooden dolls on an unusual Christmas candle had somehow come alive and were, by some means, turning the platform, when in reality it was the convention air current developed from the burning candles that caused the paddles at the top to turn. Chin (2007) stressed how important it is for the teacher to be present when learning science, during these critical moments because, 'a teacher's questions have potential as a psychological tool in mediating students' knowledge construction' (ibid:816). This reference to mediation was directly linked, by Chin, to Vygotsky's (1978) ZPD, where learning manifests and develops between what the child is capable of doing for themselves (independently) and what they were only able to do with the help of others (i.e. with a more capable other). However, notice how theories about the ZPD still requires the child to take ownership of the learning. This agency-in-learning is necessary when fostering creativity, according to Jeffrey and Craft (2004), because it provides the stimulus for the pupils to be individually expressive and to subsequently innovate. This independence of learning (or as I shall call it 'fostering of autonomy') can be achieved through the teacher actions when they *'offer independent control of the activity to the children whilst welcoming all possible ideas'*, just as the teacher did, in case C, when she invited the children to independently consider the question, *'How do I know I'm alive?'.* My definition of fostering autonomy (*italicised* above) was originally construed in the literature review, by deliberating upon the NACCCE (1999) report, the Rose (2009) review, Cremin *et al's* (2013) CLSP conceptual framework and McGregor's (2007) recommendations (see section 2.2-B.1.1.4).

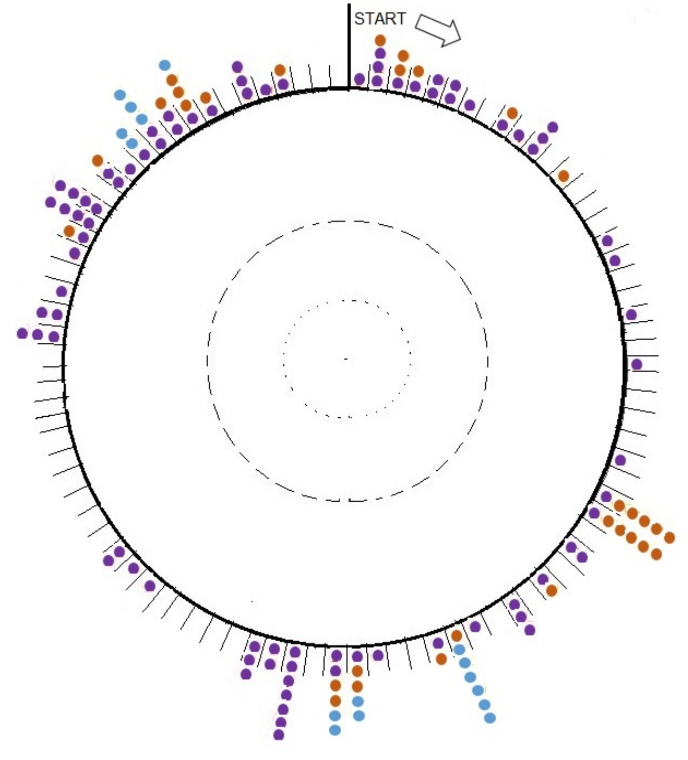
In the following section I intend to consider the context of the teachers' practices whilst they fostered autonomy. This will be achieved by first examining and reflecting upon three teaching practices (expositional, TC and T4C) through a devised observational framework/schema (described in the methodology chapter, section 5.6.2.4), whilst keeping my definition of fostering autonomy, in mind. That is, I will consider whether the teacher encouraged autonomy by speaking directly to their students (expositionally), communicating science imaginatively (TC) alongside their pupils, or whether their actions promoted children's expressions of creativity (T4C). Section 5.6.2.4.2, in the methodology chapter, provides an in-depth explanation of how I actually approached this analytical examination, and also how to read the final graphical representations produced.

7.4 Reviewing teachers' practices through the way in which they foster autonomy

The graphical representations from each of the three cases (figures 7.2-7.4), generated from the analysis (on a minute-by-minute basis) illustrated the ways teachers from each case welcomed all possible (perhaps even alternative) ideas whilst simultaneously offering opportunities for independent control of the activities to the children, through the composite components of the teaching practices. Following the figures (7.2-7.4) depiction I will discuss each case individually.





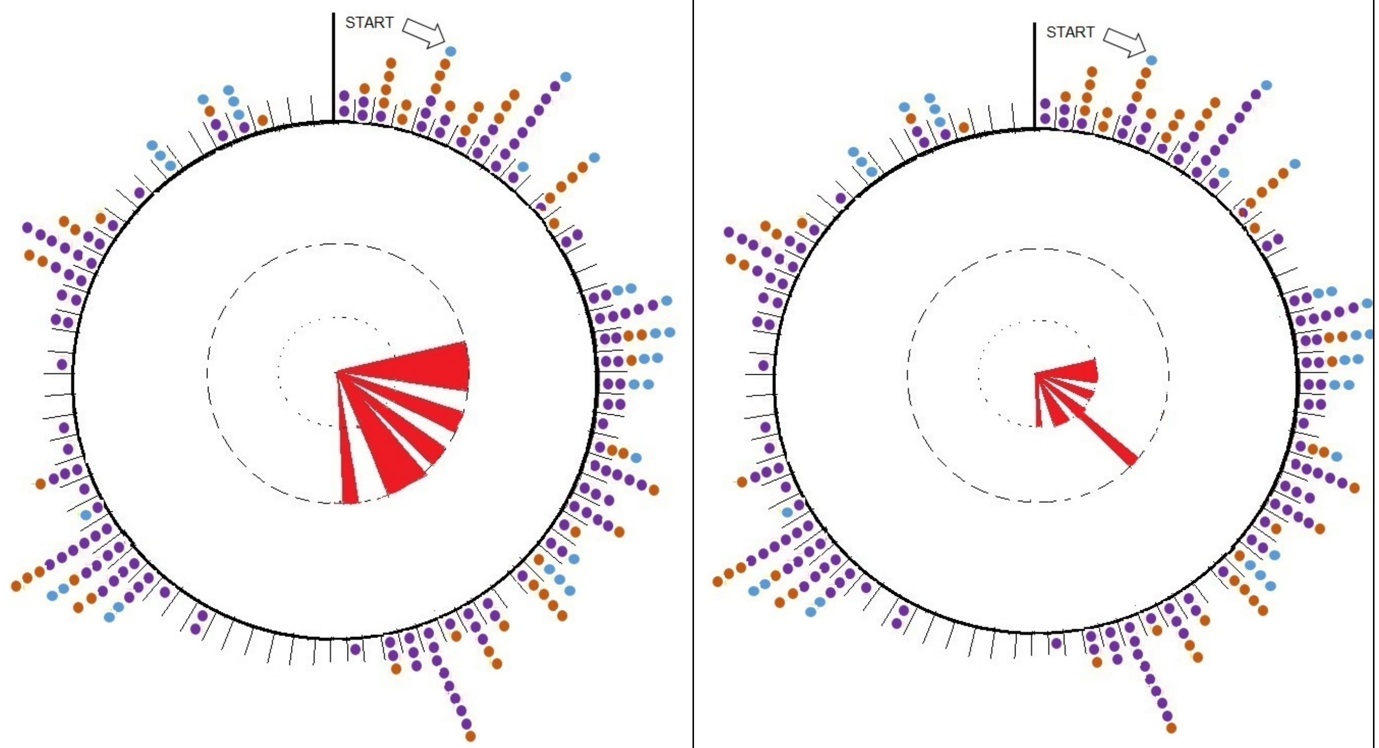


a) Conveying curricular content and monitoring factual knowing or recall of subject matter	**b)** Offering opportunities for learners to generate original ideas	**c)** Evaluating the thinking and creativity that may have arisen during the lessons/learning

Figure 7. 2: Case A: indicating where there were opportunities (when fostering autonomy) to develop creativity, with expositional teaching (inner circle), teaching creatively (middle circle) and teaching for creativity (outer circle) in mind.

The titles beneath figures a, b and c represent the teacher's intentions (see observational schema, table 5.4, methodology chapter section 5.6.2.4).

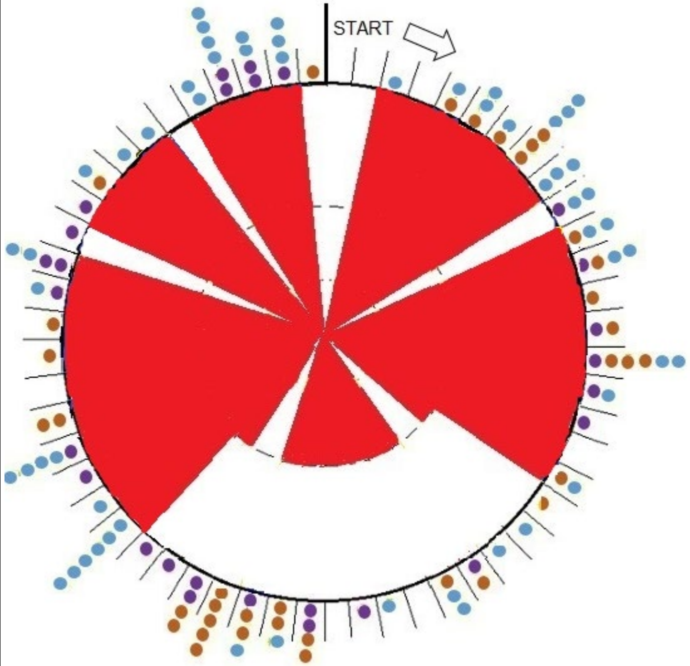
The minutes (from start to finish of the science lesson) are represented on the circumference of the largest circle through the case's question frequency timeline (see figure 7.1a). This way of displaying the time passing is duplicated in all subsequent observational graphical illustrations (figures 7.3-7.10), i.e. through their respective question frequency timelines.



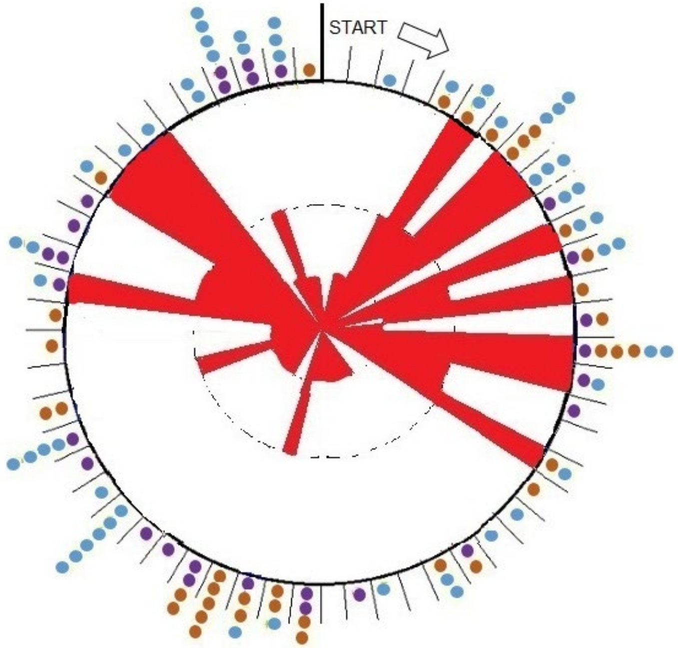
a) Conveying curricular content and monitoring factual knowing or recall of subject matter	**b)** Offering opportunities for learners to generate original ideas	**c)** Evaluating the thinking and creativity that may have arisen during the lessons/learning

Figure 7. 3: Case B: depicting which teaching practices (expositional teaching, teaching creatively and teaching for creativity) were adopted when endeavouring to foster autonomy during a science lesson.

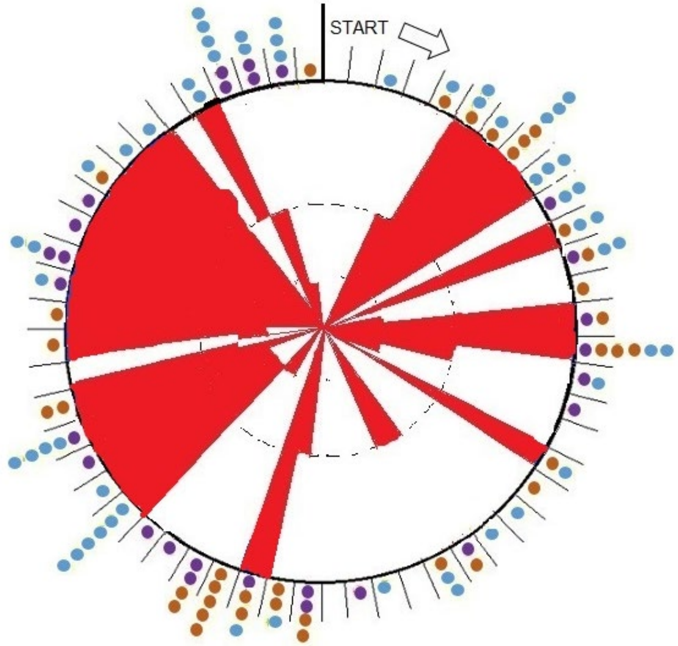
The red shaded pie-chart sections represent when (i.e. in what minute) independent learning was encouraged. This is duplicated in figure 7.4.



a) Conveying curricular content and monitoring factual knowing or recall of subject matter



b) Offering opportunities for learners to generate original ideas



c) Evaluating the thinking and creativity that may have arisen during the lessons/learning

Figure 7. 4: Case C: illustrating when there were opportunities to develop creativity through independent learning (with expositional teaching, teaching creatively and teaching for creativity in mind)

Section 7.2.1 illustrates how case A's lesson was an interactive session, packed full of interesting, unusual objects which were presented, demonstrated and described creatively, through historical tales, to pique the pupils' interest. Fascinatingly, however, child-agency was not evident throughout this lesson (see figures 7.2a-c). This is despite the teacher being open enough to allow for alternative anthropomorphic thoughts to be expressed, such as animated wooden figures moving a platform (see excerpt 5.1, in the methodology chapter, section 5.6.2.3). Does this mean that the teachers questioning technique allowed for ideas to be proffered freely, but her teaching approach was directive? My interpretation of excerpt 5.1, in the methodology chapter, appears to corroborate this idea, but I cannot say with certainty that this is true of the entire transcript without further exploration. This is why I examine five further excerpts in chapter 8 of this thesis (section 8.2).

Case B (figures 7.3a-c), in contrast to case A, indicates that the teacher nurtured autonomy during minutes 17-40. An example of this occurred post Marianne North monologue when the teacher invited the children to answer her reflective questions, in order to discern the characteristics of the scientist (McGregor and Precious, 2015). These questions included those that could be answered directly from the soliloquy itself, such as, recalling the type of transport she took to the rainforest and what Marianne actually did as a botanist/explorer. Whilst others sought a subjective understanding and involved the children thinking about, *'…the clues in what she said [during the monologue]…to tell us that she doesn't come from today?'* and, *'Who…might actually be the king or the queen at the time that this lady [Marianne North] lived?'.* These types of questions, which can have subjective answers, aptly illustrating the communication of science in imaginative ways (i.e. TC). It is also the latter open questioning style that resonates with my definition of fostering autonomy for they enabled the children to raise a variety of personalised answers, for example, one fascinating response included a child thinking that the torrential rain was the king of the rainforest. However, it was when she provided the children with the opportunity to be independently evaluative, (i.e. she invited the pupils to generate and ask their own reflective questions, an activity referred to as 'hot seating') that T4C was expressed and illuminated (see figure 7.3c). This child-led questioning phase of this particular activity is reflected upon further in the following chapter (section 8.3.2).

It is interesting to note how all three categories of teaching are evident, in case B, during minutes 17-40. Perhaps this should not have been so unexpected, after all Jeffrey and Craft (2004:85) stated that 'the former [TC] is inherent in the latter [T4C] and the former often leads directly to the latter'. They went on to suggest that, '…if these distinctions [TC and T4C] continue to be used it should be made clear that:

- ‘teachers *teach creatively* and *teach for creativity* according to the circumstances they consider appropriate and sometimes they do both at the same time.
- *teaching for creativity* may well arise spontaneously from teaching situations in which it was not specifically intended.
- *teaching for creativity* is more likely to emerge from contexts in which teachers are teaching creatively…Learners [who] model themselves on their teacher’s approach, find themselves in situations where they are able to take ownership and control and are more likely to be innovative, even if the teacher was not overtly planning to *teach for creativity’* (*ibid*).

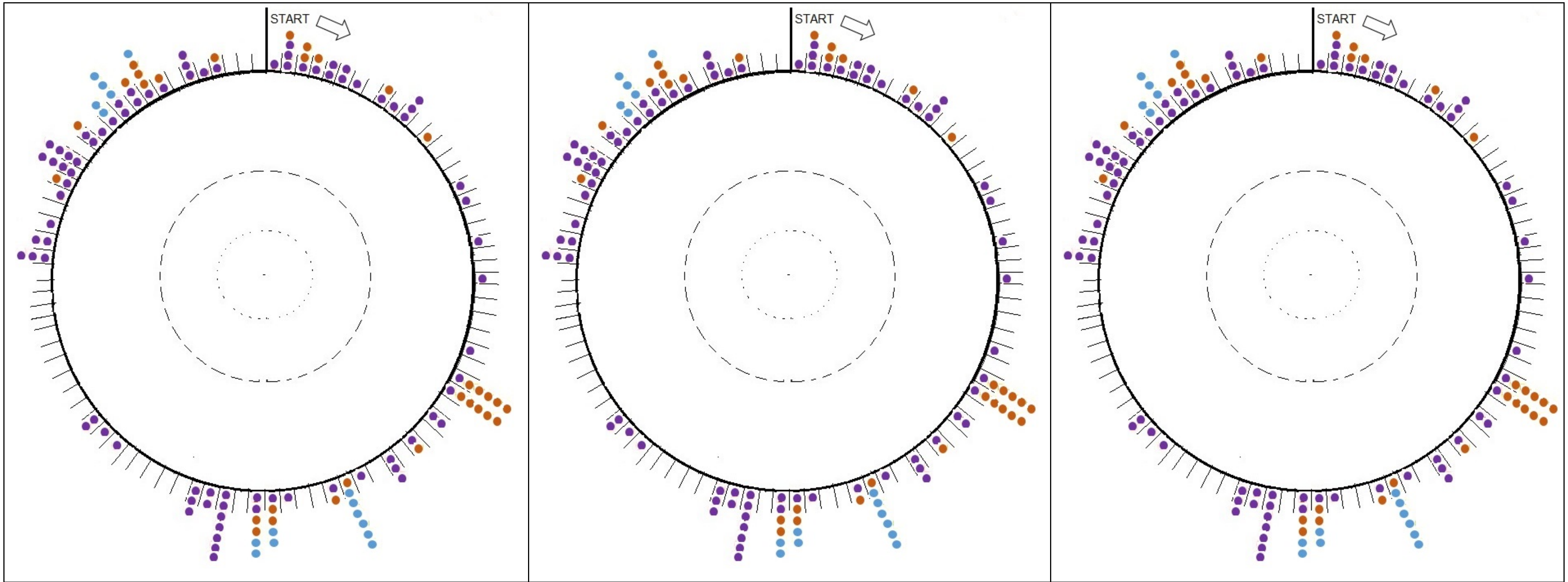
By referring to Jeffrey and Craft’s quotation above, and reflecting upon figure 7.3c, it appears that their prediction of TC and T4C simultaneously or spontaneously occurring could be correct, but I believe that the issue is far more complex than this, because, as Craft (2005) highlights, this relationship between, TC and T4C, could also be sequential. Also, notice how both practices (TC and T4C) are only featured as taking place on figure 7.3c, when the children were asked to evaluate their own performances/ideas and not through either of the other main categories (figures 7.3a and 7.3b). However, through these graphical representations I am unable to discern whether the learners took ongoing and persistent ownership of their innovation (or novel idea), or if the opportunity was just simply offered through the teacher. To consider these questions further I would need to analyse the transcript of this science lesson and include the children’s utterances as well as those of the teacher. In the following chapter I do just this to begin to answer these questions (see sections 8.3.2-8.3.3)

Moving on to case C it is interesting that figures 7.4a-c are in stark contrast to case A. These illustrations of the teacher’s practices illuminate a teacher who appears to have, at certain times, fostered autonomy through all three teaching approaches. However, yet again there are variations in sequence and timing between when these practices occurred, depending on which of the three main categories of my schema is being referred to. This serves to continue to highlight the complexities and nuances of creative teaching, and how the composite characteristics of practice piece together. To give this further consideration my first question is, what is the main difference between case C’s approach, as opposed to the other two cases? Perhaps the obvious answer could be that case C employed more open questions, as is evident through the question frequency timelines (see figures 7.1a and 7.1c). These open questions were specifically designed to develop higher order thinking (Holligan and Wilson, 2015), thereby offering more opportunities for the children to spontaneously come up with their own subjective viewpoints, which they did (see section 7.3). Thus the children would be autonomously coming up with their own new novel ideas through techniques which are designed, and initiated by the teacher (TC) to get them to think more creatively and divergently (T4C). This appears indicative of Jeffrey and Craft's (2004) explanation of T4C emerging even when teachers are being creative (TC).

As I stated before, every teacher in all three cases above appeared to allow the children the freedom to express their own creative ideas (section 7.3). However, as I also advised earlier it is also important for the teacher to be present when the children independently consider their scientific thinking, because scientific conventions (such as convection and/or the NC statutory requirements) may need to be reflected upon (Driver *et al,* 1994), especially if inappropriate inferences could unintentionally be construed as accurate conclusions if not deliberated upon further. This, I believe, is where adopting a risk-taking approach, as a teacher, can be advantageous. A risk-taker, or a teacher who takes risks, was envisaged in the literature review (section 2.2-B.1.1.3) as '*someone who is open-minded, curious and playful, and encourages the children to see things afresh by challenging ideas'*. It is interesting to consider Vygotsky's ZPD again at this juncture, because it appears that not only does consideration of this require the active agency of the pupil, for learning to flourish, it additionally requires teacher interventions, for they are perceived to be the more experienced other in this teacher-pupil dynamic. Thus by challenging the pupils' viewpoints (through my interpretation of risk-taking) the teacher becomes the critical, more knowledgable other, encouraging the expressed (and unarticulated) thoughts of a child to be made visible.

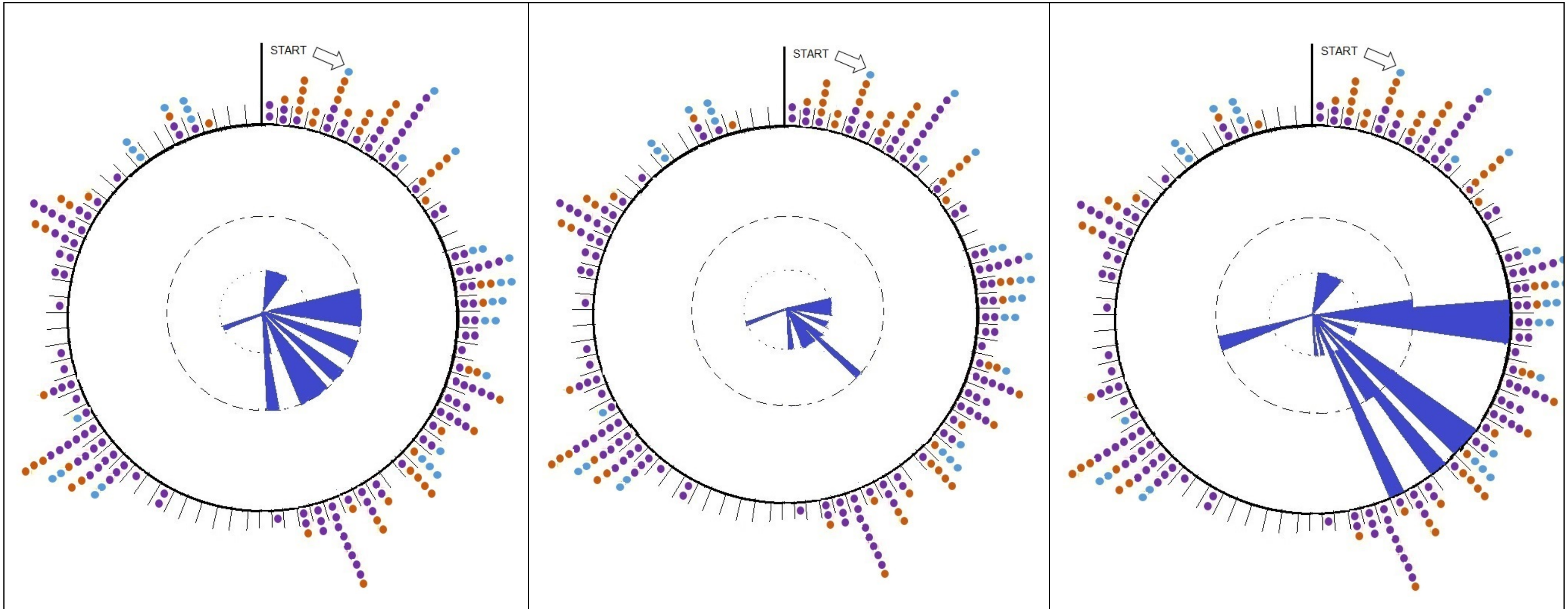
7.5 Considering the ways in which teachers take risks and challenge their pupils' ideas

These risk-taking moments, that is, when the teacher challenges the child's imaginative notions can be directive (expositional), teacher-initiated/led (TC), or developed through the child (T4C). I intend to highlight when these occurred during each of the cases (A-C) through the analytical process as described before (previously outlined at the end of section 7.2). However, this time instead of considering these observations through the lens of fostering autonomy I will keep in mind my definition of a risk-taking teacher (*italicised* above). As before, this analytical process generated three graphical illustrations, per lesson, from the observational schema, these can be found below (figures 7.5-7.7).



a) Conveying curricular content and monitoring factual knowing or recall of subject matter	**b)** Offering opportunities for learners to generate original ideas	**c)** Evaluating the thinking and creativity that may have arisen during the lessons/learning

Figure 7. 5: Case A: a graphical representation to understand when, during a science lesson, the teacher followed a risk-taking approach, through three teaching approaches (i.e. expositional teaching, teaching creatively and teaching for creativity)



a) Conveying curricular content and monitoring factual knowing or recall of subject matter

b) Offering opportunities for learners to generate original ideas

c) Evaluating the thinking and creativity that may have arisen during the lessons/learning

Figure 7. 6: Case B: illustrating when, during a science lesson, the teacher challenged the children's ideas through expositional teaching, teaching creatively and teaching for creativity

The blue shaded pie-chart sections represent when (i.e. in what minute) the teacher challenge the pupils' ideas. This is duplicated in figure 7.7.

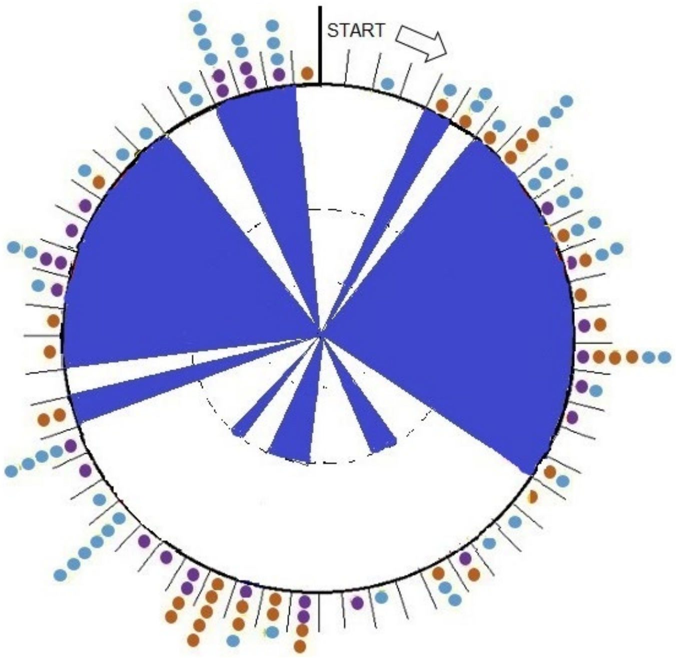
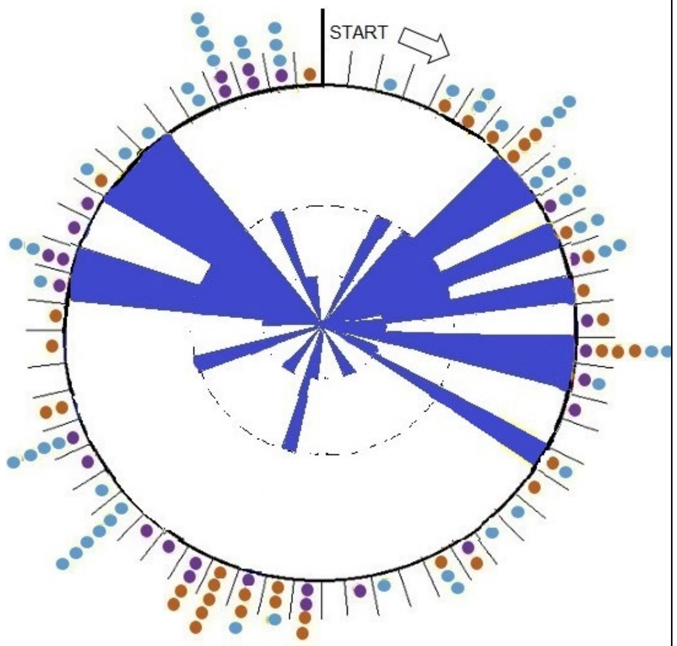
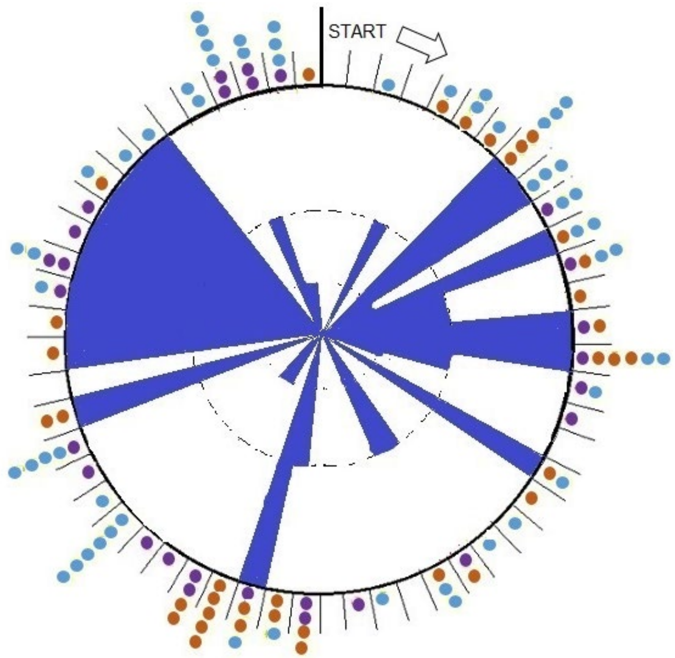
		
a) Conveying curricular content and monitoring factual knowing or recall of subject matter	**b)** Offering opportunities for learners to generate original ideas	**c)** Evaluating the thinking and creativity that may have arisen during the lessons/learning

Figure 7. 7: Case C: indicating when, during a science lesson, the teacher adopted a risk-taking approach using either expositional teaching, teaching creatively or teaching for creativity practices

Previously figures 7.2a-c indicated that the teacher, in case A, had not encouraged agency-in-learning, and subsequent inspection of figures 7.5a-c points out that the articulated thoughts and ideas of the children may not have been critically challenged either (note the absence of any risk-taking behaviours). Referring back to excerpt 5.1, in the methodology chapter, the teacher could have taken a risk and challenged the child's anthropomorphic answer (section 5.6.2.3). This could have been followed by connecting the expressed thoughts with the scientific (i.e. the convection current produced by the candles and its effect on the paddles at the top of the carousel). Nevertheless, to generalise from this one moment as being indicative of the entire lesson is unfair, for it is only a one minute excerpt of an entire lesson which lasted 92 minutes and thus further examination of choice interactions between teacher and pupil(s) will be considered later on in this thesis (in chapter 8, section 8.2).

After giving further thought to case A (or more specifically figures 7.2 and 7.5) I considered the mediatory practices involved in developing the ZPD. I thought about what would happen if a teacher had not fostered autonomy (as illustrated through figure 7.2), nor been a risk-taker (as indicated by figure 7.5); would this have meant that the children's ZPD may not have been advanced? It was upon considering this that I noted how figures 7.6a-c (case B: risk-taking) and 7.3a-c (case B: encouraging autonomy) both had striking similarities. It appears that between minutes 17-40 the teacher was concurrently encouraging independent learning whilst challenging the children's ideas. There is also a comparable relatedness between figures 7.4 and 7.7, which represents case C's approach towards autonomy and risk-taking respectively. The teachers' risk-taking nature, in case C's lesson has been referred to before, in section 7.3. Having conceptualised Vygotsky's ZPD as requiring both agentive learning and appropriate challenges, by the teacher, I am left wondering if mediatory practice could be illuminated somehow through cases B and C, seeing as both features (risk-taking and nurturing autonomy) were illustrated in their respective representative figures. Having asked this question I have endeavored to answer it in the following chapter through the examination of teacher-child interactions.

It is imperative, however, to contemplate Brown and Ferrera's (1985) definition of Vygotsky's ZPD, as was suggested in the literature review (section 2.2-B.1.1.2), because Bredo (1999) was concerned that Brown and Ferrera's explanation of this mediatory practice perceived the child as a passive receiver of knowledge, separated from their social environment. Thus it could be argued that if the learners were not invited to express their critical reflections, alongside the teacher's critique, they would have been socially separated from the more experienced other when formulating their own subjective conclusions. It was previously argued, in the literature review, that this lack of social interaction (between teacher and child) left little room for creativity (Rogoff, 1995). Thus to elucidate the pupils creativity-in-learning (or reifications of critico-creative practice) I would have to first clarify the nature of the social interactions taking place. For this I need to refer to and critically examine the actual transcripts, of all three cases, for any verbal exchanges taking place. I have, to this end, subsequently interpreted these dialogic interactions through the observational schema. The results can be found in figures 7.8-7.10, in the following section of this chapter.

7.6 Highlighting when verbal interactions, between teacher and pupil(s), take place during science lessons (cases A-C)

Donaldson (1987) cited in McGregor (2003) suggested that relationships can be built-up in the classroom by the teacher encouraging their pupils to use their own voices, to make sense of their own understandings. This has been previously linked to development of a child's ZPD in the literature review (2.2-B.1.1.2). McGregor believed that this kind of mediatory practice could be reified through studying the verbal exchanges taking place in the science classroom. Figures 7.8-7.10 highlight when these social interactions occurred in cases A-C, through my observational schema. These illustrative diagrams also depict which teaching approach the teacher adopted when these teacher-pupil conversations took place.

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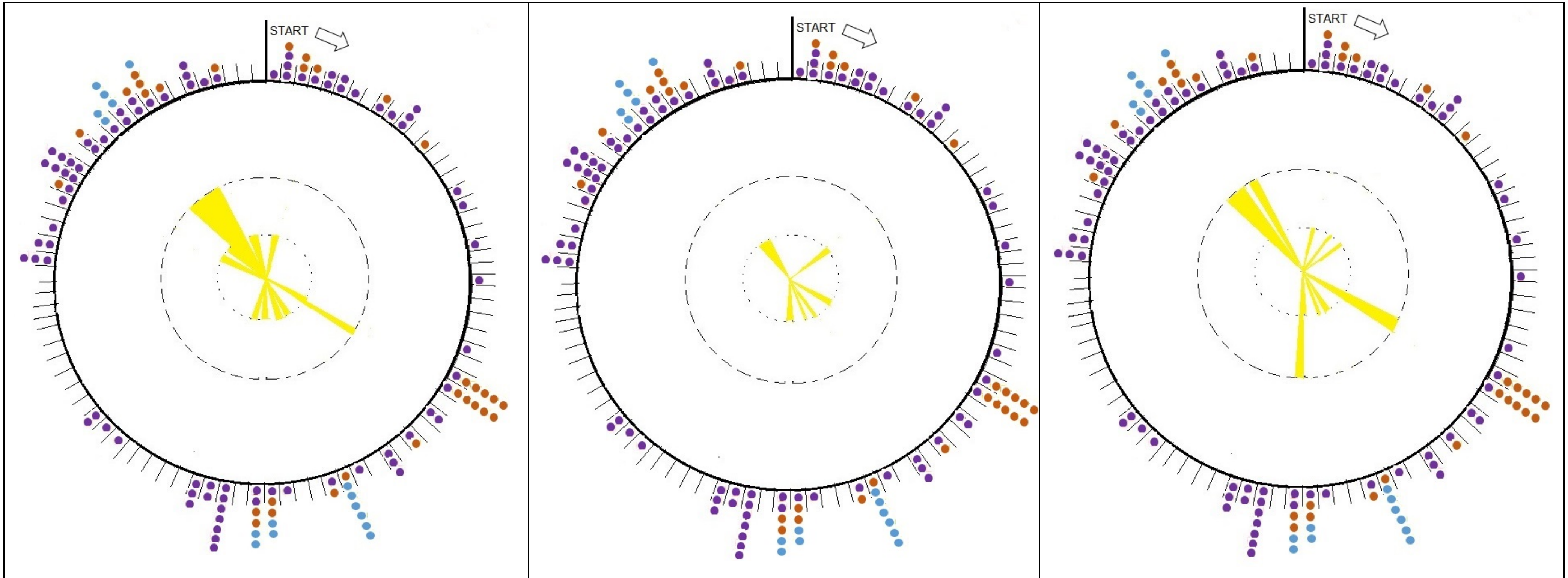
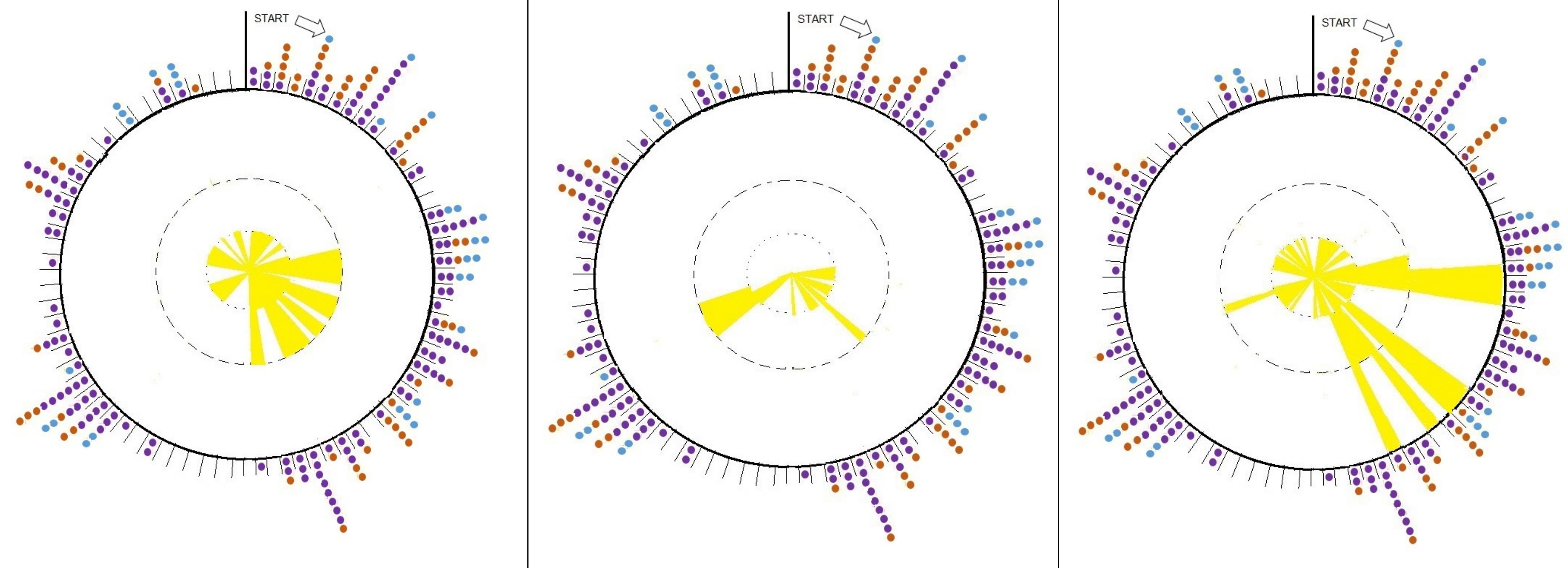


a) Conveying curricular content and monitoring factual knowing or recall of subject matter	**b)** Offering opportunities for learners to generate original ideas	**c)** Evaluating the thinking and creativity that may have arisen during the lessons/learning

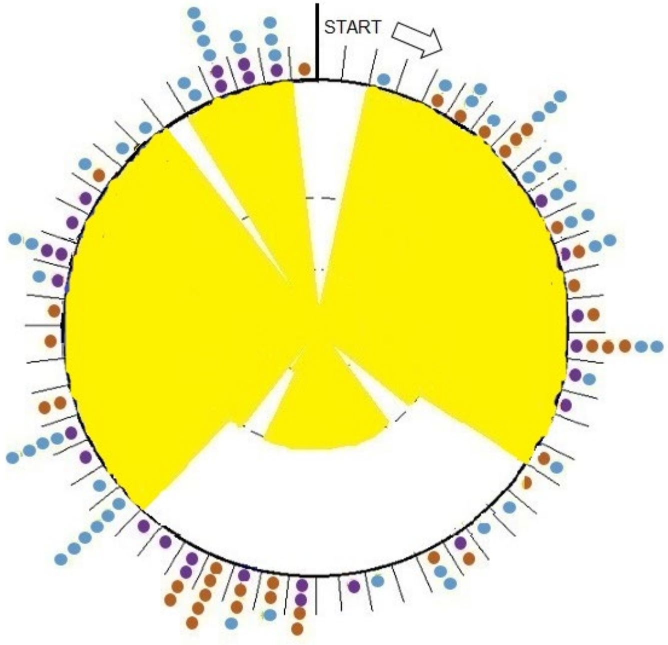
Figure 7. 8: Case A: illustrating when verbal interactions take place during the science lesson through three teaching practices (expositional teaching, teaching creatively and teaching for creativity)

The yellow shaded pie-chart sections represent when (i.e. in what minute) verbal exchanges take place between the teacher and pupils. This is duplicated in figures 7.9-7.10.

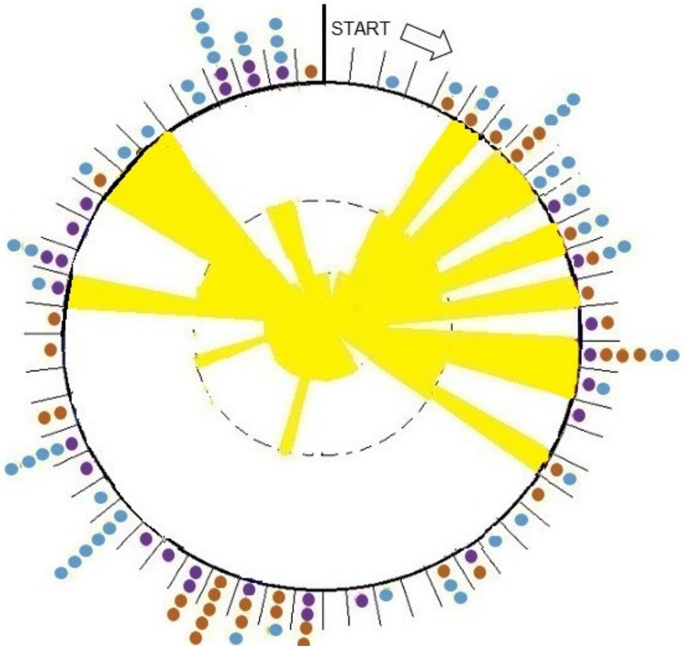


a) Conveying curricular content and monitoring factual knowing or recall of subject matter	**b)** Offering opportunities for learners to generate original ideas	**c)** Evaluating the thinking and creativity that may have arisen during the lessons/learning

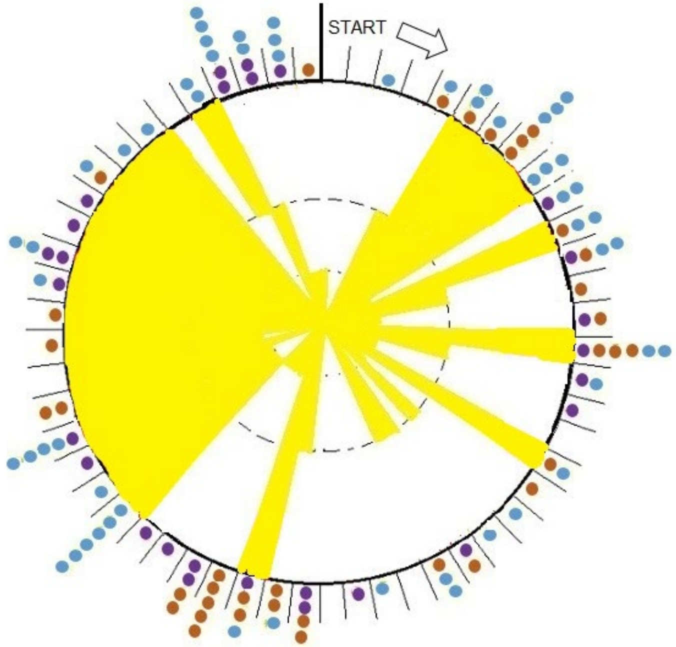
Figure 7. 9: Case B: depicting in which minutes verbal interactions occur during the science lesson, with expositional teaching, teaching creatively and teaching for creativity in mind



a) Conveying curricular content and monitoring factual knowing or recall of subject matter



b) Offering opportunities for learners to generate original ideas



c) Evaluating the thinking and creativity that may have arisen during the lessons/learning

Figure 7. 10: Case C: indicating when verbal interactions (through expositional teaching, teaching creatively and teaching for creativity) take place during the science lesson

It is interesting to note that the teacher in case A did, in reality, communicate with her pupils on numerous occasions albeit lacking explicit development of children's independent learning or challenging their ideas (see figures 7.2a-c for fostering autonomy and 7.5a-c for risk-taking). The verbal exchanges that took place appeared to be mostly reflected through figure 7.8a, when the teacher conveyed curricular content and monitored factual knowing or recall of subject matter. Whilst these interactions were chiefly interpreted as being expositional in nature there were minutes when she simultaneously achieved this creatively (i.e. through TC). Interestingly when ideas were evaluated (see figure 7.8c) this was achieved, in the main, by both TC and directive (expositional) approaches. However, there were fewer communicative exchanges when generating ideas (figure 7.8b) and when these did occur they were reportedly directive in their nature. It will be fascinating to know what was said during case A's interactions because previously I had wondered if the child's developing learning had been accessed. To this end I will examine and consider five verbal exchanges in the following chapter of this thesis (section 8.2).

In figures 7.9a-c (case B) the teacher's interactions appeared to mainly take place during minutes 17 and 40, the same time period in which the teacher encouraged independent learning and took risks (see figures 7.3a-c and 7.6a-c respectively). The teacher's verbal exchanges, in case C (depicted in figures 7.10a-c), are also akin to their respective illustrations, i.e. figures 7.4a-c, which illustrates when the teacher fostered autonomy and 7.7a-c when she took risks and challenged ideas.

It will be interesting to examine the types of exchanges taking place during case B's science lesson, between minutes 17-40, and then to compare this to what was being said during the second half of the science lesson, where no autonomy or risk-taking was reported. This can be found in section 8.3 of the following chapter and may illuminate whether (or not) autonomy and risk-taking reified the child's developing learning (within the ZPD). I also plan, in section 8.5, to contrast case B's and case C's interactions because the higher order thinking techniques employed in case C reportedly promoted exploratory interactions (Gillies and Khan, 2009).

Whilst the graphical representations provide a relational illustration of the teachers' practices, highlighting particular features as and when they occur, during the science lesson, this type of observational framework, O'Leary (2014) stated, makes a multifaceted subject, such as the development of creativity, appear rather generic. In the methodology I acknowledged that there were a number of further ways that a teacher could promote creativity within the primary science classroom (see section 5.6.2.5) and recognised that the ‘generic’ depictions of particular features of the teachers’ practices (figures 7.2-7.10) fell short of illustrating the actual affordances the teacher made available.

It was Mercer and Hodgkinson who first produced a ‘map of events’ (*ibid*: 125-126) which highlighted (in words), sequentially, the key activities/strategies adopted to mediate the social actions of both the teacher and learner from the beginning to the end of a morning classroom session. Through contemplating Mercer and Hodgkinson’s events map and considering other researcher’s ways of graphically representing their classroom data (Mortimer *et al*, 2015) I understood that the specific activities undertaken during observed science lessons, the teacher’s (and/or pupil’s actions) and social interactions could be represented in a similar fashion (see figures 7.11-7.15 below).

7.7 Illustrating sequential activities, actions (teacher and pupil) and social interactions which occur during science lessons.

The graphical representations (figures 7.2-7.10) had admittedly oversimplified the nature of the classroom interactions (O’Leary, 2014) which support creativity. Thus I needed to view a richer data set, bound within the same location to answer my second RQ more thoroughly (Swanson and Holton, 2005). This is why the graphical representations will also be cross-referenced with the event maps. It was my intention that, by examining a map of time-lined events (activities, teacher/pupil actions), in sequential order, it would become possible to draw attention to the various creative opportunities the teachers made discernable during the science lesson (e.g. see figure 7.11a-b for case A’s events map). To highlight chronologically these representative moments within the science lesson the question frequency timeline (see figure 7.1a) was represented in its original linear format (compare figure 7.1a to figure 7.11b below).

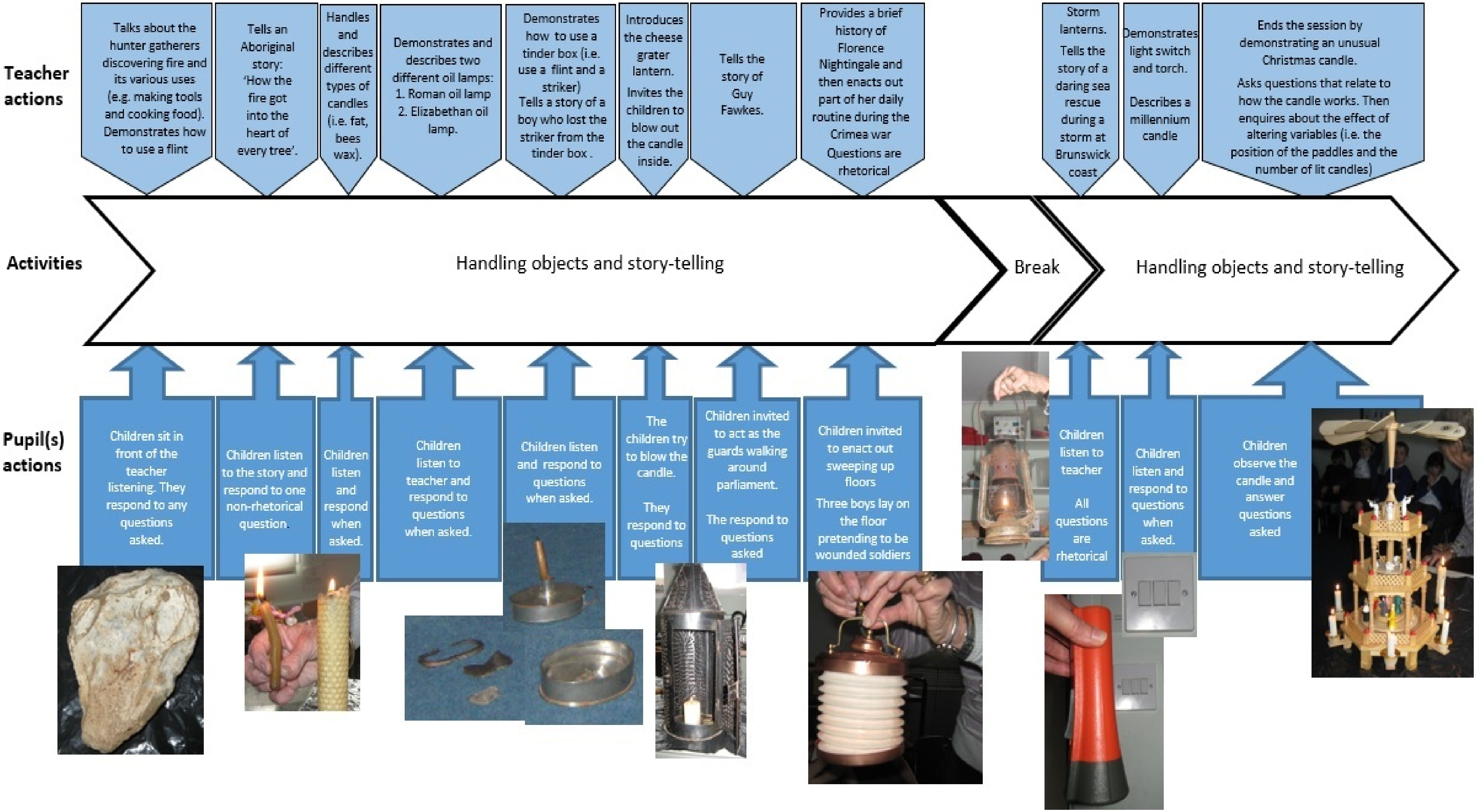


Figure 7. 11a: Case A: events map (part 1)

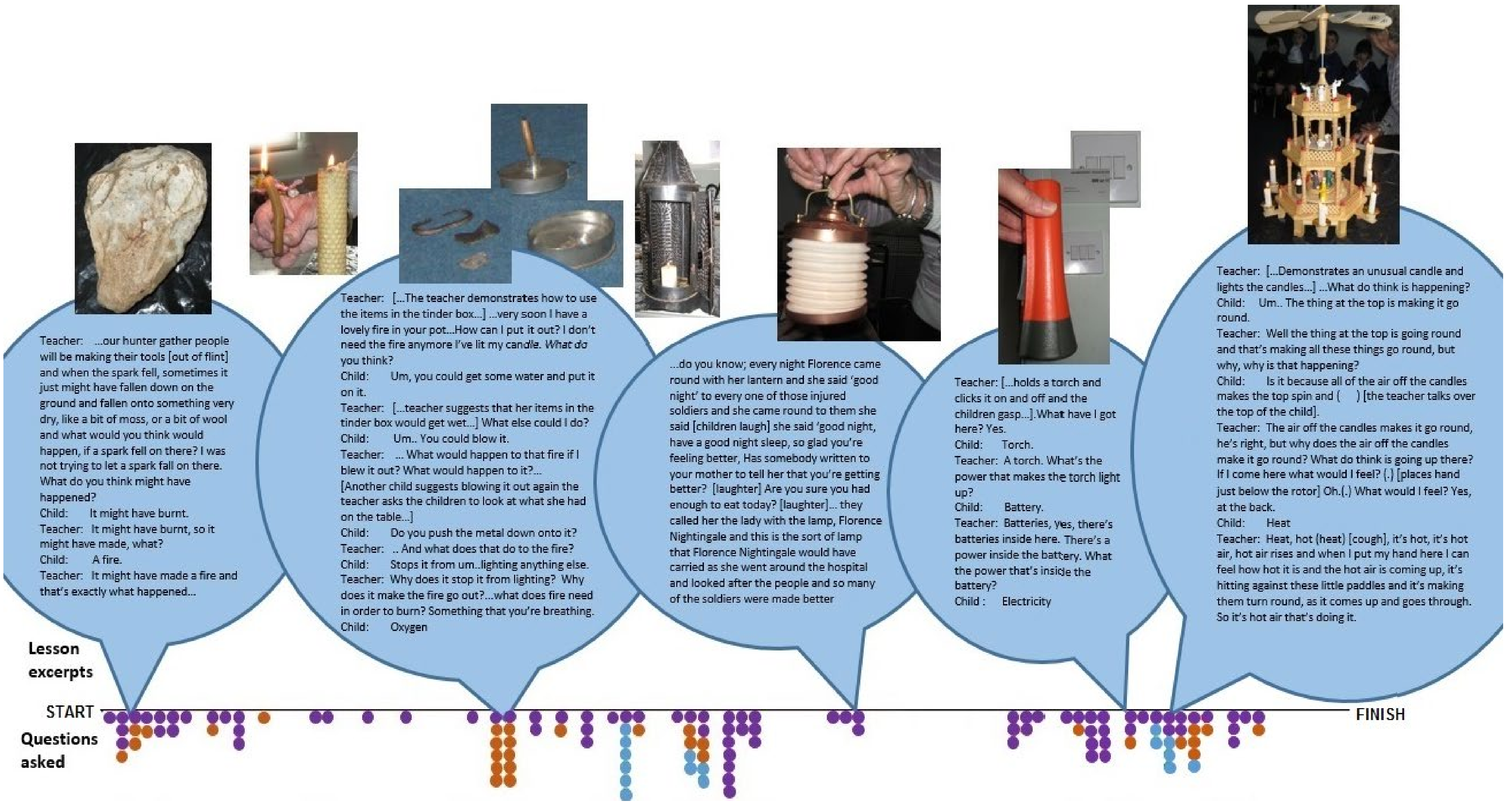


Figure 7.11b: Case A: events map (part 2)

7.7.1 Examining case A's events map

The activities employed by the teacher, in case A, are made visible in figure 7.11a. These are represented in a sequential sequence along the center of the page, from left to right, and have been appropriately sized (in length) to align with the minutes on the question frequency timeline found on figure 7.11b. According to the written text on the activity timeline the teacher employed a story-telling approach throughout the entirety of the science lesson, except for a short six minute break, which took place two-thirds of the way through the session (minutes 61-67). The stories the teacher told were associated with various unusual objects, some of these items were illustrated (as photographs) on both 7.11a and 7.11b.

It is through the examination of the text, on the teacher/pupils action timelines, that it becomes possible to interpret who (teacher/child) initiated the creative act and/or who the activity is focused around, for example, the written text on figure 7.11a indicated a teacher-led approach, for it depicts the children either sitting and listening, whilst responding to questions, or performing a directed enactment, such as, pretending to be guards in the Houses of Parliament (minutes 47-49).

Whilst the events map provided yet another illustrative perspective, in a more explicit and sequential way, of happenings at the teacher and/or pupil level, it did not provide the rich details to elucidate how the teacher was developing the children's learning and/or creativity. To try and bridge this gap figure 7.11b offers five illuminatory episodes of talk (encapsulated in speech bubbles). These extracts were chosen from the transcripts because they highlight illocutionary and perlocutionary acts, i.e. I can focus on the speakers and what they are doing through their vocalisations and how these utterances are received by the listener (Austin, 1975, cited in Bird, 2011:94-95). The analytical process is described in more depth in the methodology chapter, section 5.6.2.6. Each of these extracts have been tied into particular events (i.e. the activities/stories) through the photographs of the unusual objects and the question frequency timeline. The verbal exchanges taking place in these excerpts were selected and filtered for analysis, to establish how a teacher's practice is related to the emergence of creativity. The examination of these excerpts can be found in chapter 8 of this thesis (section 8.2).

As well as creating and examining an events map for case A I also wanted to draw attention to the different ways in which the teachers', in cases B and C, had provided creative opportunities through their own respective events maps (see figures 7.12a-b and 7.13a-b below).

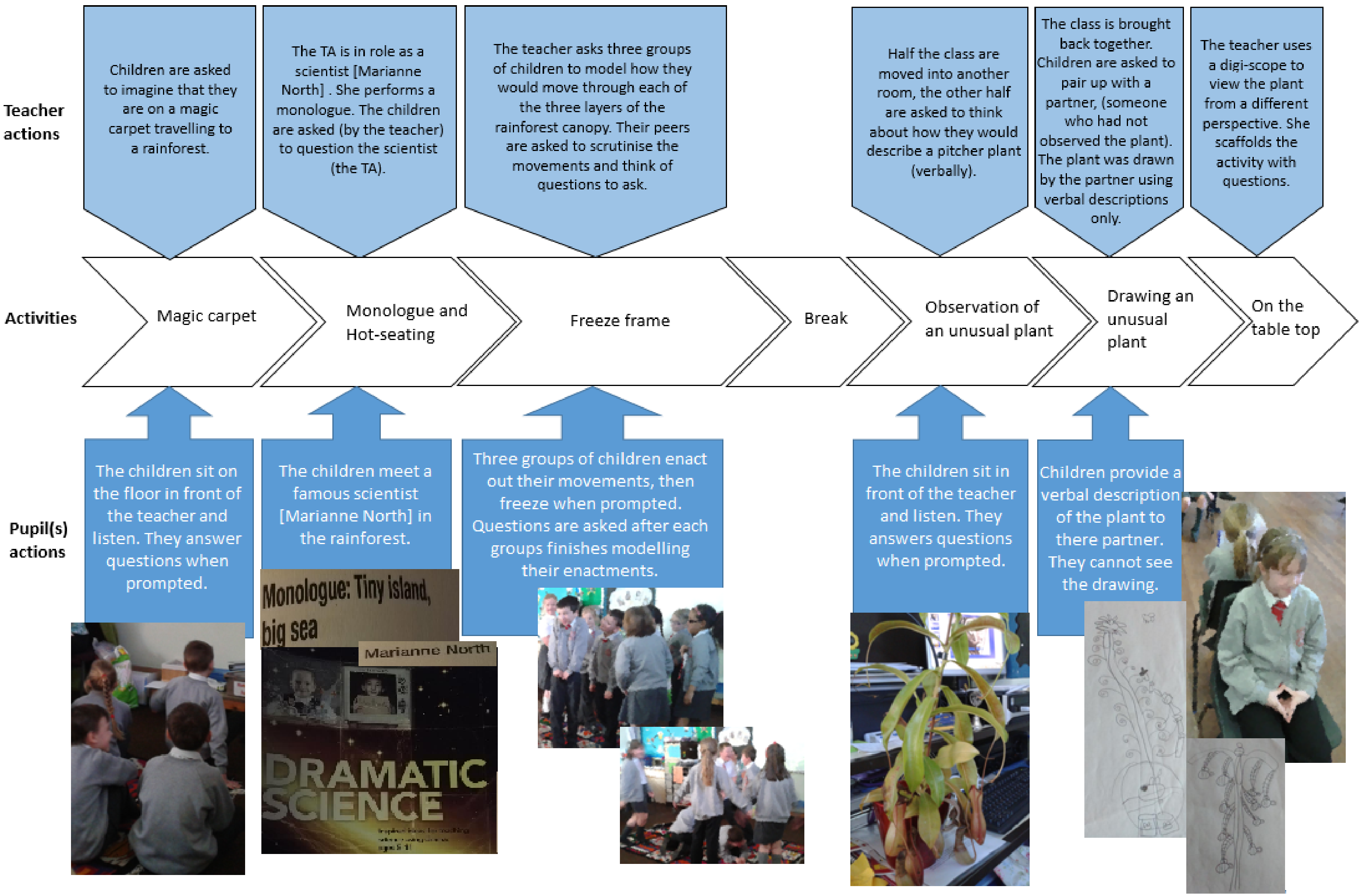


Figure 7. 12a: Case B: events map (part 1)

Figure 7.12b: Case B: events map (part 2)

7.7.2 Analysing case B's events map

Earlier in this chapter my interpretation of observations of case B suggested the teacher had adopted an approach which combined all three teaching practices (expositional, TC and T4C) during minutes 17-40 (see figures 7.3, 7.6 and 7.9). As well as 'hot seating' (which was described in section 7.4) another activity, which reportedly took place during this specified time period, is referred to on figure 7.12a as being a 'freeze frame'. The teacher actions, as described above this activity, imply that the pupils were invited to act out (i.e. physically represent) the movements required to traverse the different layers of the rainforest canopy. The teacher's actions, also indicated that the rest of the class were invited to review their classmates' enactments and consider questions to ask their peers for clarification and verification, which they reportedly do post performances (see pupil actions). This is indicative of an approach which is teacher-initiated but orientated towards pupil self-expression, an approach, which was arguably akin to Davies' (2011) descriptions of both TC and T4C. In the following chapter I examine the question and answer session between the children, post modelling, in order to appreciate the nature of the exchange (see section 8.3.3).

I also noted earlier that it would be interesting to consider why the second half of this lesson appeared to be of a directive nature, because for the most part, during these last 34 minutes, when the verbal interactions were tangible, the exchanges were reportedly expositional (see figures 7.9a-c). There also appeared to be no encouragement of independent learning (figures 7.3a-c) and very little risk-taking (figures 7.6a-c) during this stretch of time. According to the descriptions on the events map, in the latter half of this science lesson, there was an observation of an unusual plant. The half of the class which remained with the teacher at this juncture were depicted (through the pupils' actions) as sitting down in front of the teacher, so they could listen and answer questions when prompted; thus I have interpreted this as being teacher-directed. This observation was followed by the drawing of the unusual plant, here the teacher and pupil actions portray the children as working independently of the teacher at this time. However, the physical actions of both the teacher and/or children, throughout the events map, may not clarify the full nature of the interactions taking place, and thus I offer five excerpts, two of which occur in the second half of the lesson, in figure 7.12b, for consideration. The examination of the five excerpts will take place in the next chapter and the analysis of the two interactions, in the second half of the lesson, will be found in sections 8.3.4 and 8.3.5.

In contrast to case A and the second half of case B, the third science lesson depicted a teacher practice which incorporated all three teaching approaches on numerous occasions (see figures 7.3, 7.6 and 7.10). I will try to illuminate this by next examining the events map of case C.

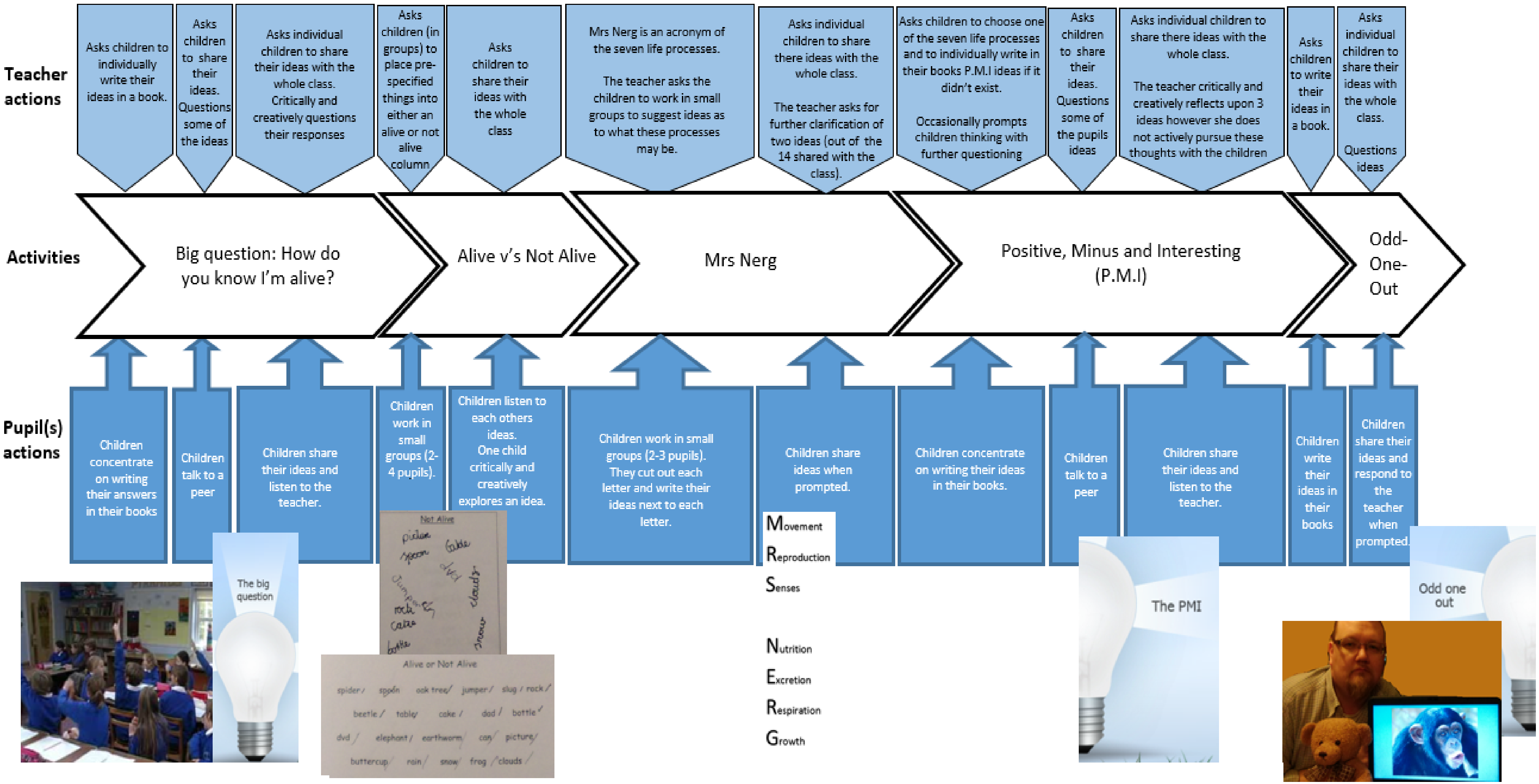


Figure 7. 13a: Case C: events map (part 1)

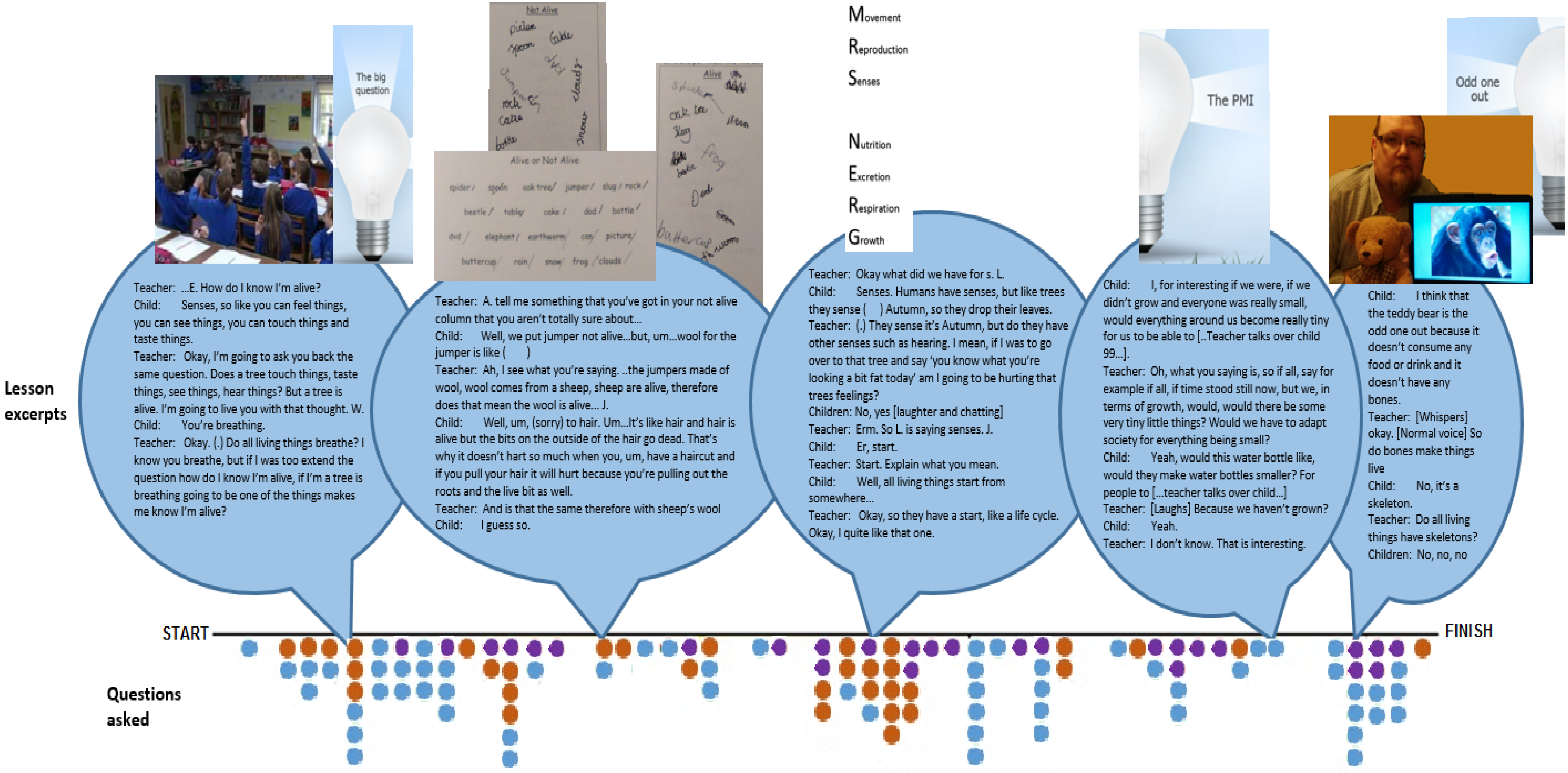


Figure 7.13b: Case C: events map (part 2)

7.7.3 Considering case C's events map

In section 7.3-7.5, I described the teachers' practice, in case C, on occasions, as drawing on all three teaching practices (expositional, TC and T4C) through fostering autonomy, risk taking behaviour and via the verbal exchanges taking place (see figures 7.4, 7.7 and 7.10 respectively). I even suggested that this may have occurred, in part, because the strategies employed supported higher order thinking (Hanley *et al,* 2015). By examining the events map (figure 7.13a) the sequential activities employed are made visible. According to the teacher actions, during the majority of these tasks, the teacher invited the pupils to be actively involved; notice how she appeared to be asking the children to consider and share their own thoughts and ideas and not overly directing the task herself. This suggested an approach which (although teacher-initiated) incorporated the children's own thinking (it was child-led). That is, it appeared orientated towards enabling the pupils to independently express their thinking for themselves.

Furthermore the teacher also appeared to consider the pupil's expressed thoughts, for example she asked for further clarification of ideas during the Mrs Nerg activity (minutes 29-35). The events map also highlighted the teacher critically and creatively responding to the pupils' ideas during certain tasks, e.g. during the big question, (minutes 6-12) and the PMI activity (minutes 43-50). This could imply some form of exploratory thinking but how the learning was reified post teacher-led evaluation is not clarified and I am unable to elude if the children's critico-creative practice was reified. To further appreciate the learning and/or creativity that may have transpired during these teacher-child exchanges, five verbal exchanges which took place during the activities were selected (see figure 7.13b) and these will be examined in the following chapter of this thesis (section 8.4).

7.8 Summarising and reflecting upon the examination of three primary school science lessons

During this chapter I have endeavored to illuminate teaching practices which can support creativity by examining three cases, through three different means. First, I inspected the types of questions each teacher asked throughout the science lesson (closed, pseudo-open and open), then reflected upon the teaching practices the teachers adopted (expositional, TC and/or T4C) from three pedagogic perspectives (fostering autonomy, risk-taking and through the verbal exchanges taking place) and, finally I illustrated the activities undertaken, and examined the teacher/pupils actions during these tasks.

The questions asked by the teacher (whether closed, pseudo-open or open) emotionally engaged the children enough to enable them to freely express their ideas (alternative or not). However, I realised that questioning is only one component of the many interpersonal interactions which take place during one science lesson. For example, open-ended statements could also, reportedly, lead to exploratory interactions. These interpersonal levels of communication are, according to the literature review, developed through the teachers' mediatory practices and could, if appropriately employed by the teacher, reify creativity-in-learning (see section 2.2-B.1.1.2). These exchanges may even reveal the spirit of AfL (i.e. it could illuminate a formative assessment practice that is already naturally integrated into the flow of the lesson) responding to RQ4.

When mediating these interactions it was suggested, in section 7.4, that the learners would need to somehow take independent control of their learning. This could be supported by a teacher who offers their pupils agentive control of the activity/task (i.e. the teacher fostered autonomy). In section 7.5, I pointed out that the more experienced other (the teacher) is not to be neglected when fostering autonomy, after the loci of ownership is handed over, for it is they who challenge the pupils' ideas, especially if scientific conventions are being considered (i.e. the teachers become risk-takers). It is with these two features in mind (fostering autonomy and risk-taking) that three practices (expositional teaching, TC and T4C) were reflected upon through an observational schema. Graphical illustrations were subsequently generated, and they indicated when (in which minutes) the teacher's practice reflected each feature through the three teaching approaches named above. Unfortunately these graphical representations could not elucidate whether the children went on to critically and/or creatively reflect upon the scientific content being taught/expressed by the teacher. To appreciate when creativity-in-learning could be reified through these critical interactive moments I highlighted the points at which any verbal exchanges took place using the same observational schema, and this produced further illustrations for consideration.

Whilst the graphical representations provided an instantaneous way of indicating which teaching practice had been adopted during each science lesson, when the teachers either fostered independent learning or when they challenged the pupils' ideas, I still needed to view a richer data set to continue to elucidate further features of creative practice that supported creativity, to continue to respond to RQ2. To this end, events maps were created which illuminated the activities taking place, and the teacher and pupil salient actions, throughout the science lesson. These were chronologically tied to the nature of questions posed and frequency timelines to provide a way of revealing whether an activity was teacher-led/initiated or child-led/initiated. However, to further appreciate whether learning and/or creativity transpired during these activities, five verbal exchanges, which took place during each science lesson, were selected per case (these are also tied to the question frequency timeline). They are examined in the following chapter of this thesis in order to elucidate whether creativity-in-learning can be reified through a naturally embedded practice (i.e. through verbal exchanges).

Having conceptualised analytical methods and tools to visually examine how a teacher promotes creativity in a single primary science lesson, I have to acknowledge that I have not considered how every participant (teacher and student) individually interacts with its development and likewise, how these numerous creative realities can be (and are) formed via these subjective experiences (Sawyer, 2012). That is, by illustrating the research data in the manner in which I have, these unique perspectives cannot (and have not) been illuminated. Nevertheless, by endeavouring to elucidate creativity from within the social interactions (i.e. through teacher-child verbal exchanges), in the following chapter, I can potentially further appreciate and validate how these emerging creative realities can be formed and observably assessed.

Chapter 8

Clarifying the nature of the teacher-child interactions in cases A-C

8.1 Aims of clarifying teacher-child interactions

In this chapter I examine five excerpts of verbal interactions from each of the three cases (A-C). These five episodes from the transcripts were chosen because they highlight illocutionary and perlocutionary acts (Austin, 1975, cited in Bird, 2011:94-95). These focus on two aspects, they are: the speakers and what they are doing through their vocalisations, followed by how these utterances are received by the listener (*ibid*). This is described in more depth in the methodology chapter, section 5.6.2.6. Similarly to Bird's (2011) doctoral thesis I filtered examples from the transcriptions of classroom activity to illuminate the extent of creativity being demonstrated, and additionally, to establish when they happened, they were integrated into their respective events maps (see figures 7.11a-b, 7.12a-b and 7.13a-b, section 7.7) ready for further comparison. It is hoped that these fifteen excerpts will clarify how these verbal interactions may (or may not) promote creativity in science lessons. This mutual venture between teacher and child has been previously identified as 'exploratory dialogue' (see literature review 2.2-B.1.1.2) and has been construed as a form of dialogue which reaches for an idea (and/or product) through mutual critical and constructive negotiation. A description which is akin to Fisher's (2001) critico-creative thinking (as originally described in section 2.2-A.3.3) - it is this type of verbal exchange which I have previously suggested can reify the extent of creativity-in-learning. However, Bird (2011) challenged the view that only exploratory talk was of educational value and suggested that it was important to consider all forms of communication within the educational learning environment, because they can all potentially signify some form of participation, even if only on an intrapersonal level (i.e. internally with oneself). I have taken Bird's advice and kept in mind all three of Mercer's types of talk (disputational, cumulative and exploratory) and combined these with Alexander's lesser-known five patterns of teacher talk (rote, recitation, instruction, discussion and dialogue) to generate a more comprehensive theoretical framework to consider how to interpret verbal classroom communication (see section 2.2-B.1.1.2). This framework is applied to make sense of the nature of the interactive talk and I depict each of these available types of classroom talk illustratively in a summarised table (see table 2.1 in the literature review).

Throughout this chapter I will refer to the observational graphical illustrations and the events maps from the previous chapter when appropriate, for it is my intention to cross-reference any findings from my observational analysis to answer questions generated in the previous chapter.

Before I describe the results of my examination I feel I need to reaffirm something I suggested previously, in chapter 7, section 7.8. In this aforementioned section, I acknowledged that exploratory interactions could not only potentially reify creativity-in-learning but they could also illuminate a formative assessment practice that is (or can be) naturally integrated into the flow of the lesson (i.e. the spirit of AfL) and it is this, I had reasoned in the methodology chapter (section 5.6.2.6), that could respond to research question (RQ) 4. I intend to answer this fourth RQ by examining each of the 15 excerpts whilst keeping Bird's description of the spirit of AfL in mind.

Bird (2011) described this embedded formative learning technique through Marshall *et al* (2007) '…as genuinely promoting learner autonomy by encouraging engagement in the processes of and criteria for completing work…. (*ibid*:98). This is opposed to the 'letter of AfL' where

> '…procedural activities associated with AfL (like peer and self-assessment or questioning) are used but mainly to determine 'right' answers or the 'right' ways of doing things often with a specific and explicit focus on performance rather than learning' (*ibid*:98).

So I, like Bird, to illuminate the spirit of AfL will be examining the excerpts for '…speech-acts which position pupils as agentive learners' (*ibid*:98) as opposed to the letter of AfL which emerges through '…speech acts which position pupils as passive and the teacher as arbiter of knowledge [through] an interchange….[in which] meaning remains tacit' (*ibid*:98-99). In brief, to illuminate the spirit of AfL, I will be looking for the child's participation through their developing knowing, as opposed to a passive acquisition of knowledge (Sfard, 1998).

8.2 Illuminating the nature of the teacher-child classroom dialogue in case A through five excerpts

In the preceding chapter case A's events map (figure 7.11a, in section 7.7) clarified what types of activities were taking place during the science lesson. That is, the teacher was piquing the children's interest creatively by demonstrating unusual lamps (and sources of light and fire) through a story-telling narrative. To further appreciate if the conversations that took place during this science lesson elucidated creativity and/or illuminated the spirit of AfL I have examined the five excerpts tied to the events map (see figure 7.11b).

8.2.1 The hunter gatherers

By examining when the excerpt below took place on the events map (at minutes 2-3) I am able to discern that the children were listening to the teacher recounting a historical tale of the hunter gatherer people discovering fire and that they responded to her questions when prompted to do so.

Excerpt 8.1 is a sub-section of a creative episode that I had previously examined in the methodology chapter (section 5.6.2.4.2). I referred to this part of the transcript, in chapter 5, to provide an explanation of my initial interpretation of the teacher's practices, via a devised schema (table 5.4). I offer it in this chapter to clarify the nature of the audibly available exchanges taking place.

Teacher	And our hunter gatherer people will be making their tools and when the spark fell, sometimes it just might have fallen down on the ground and fallen onto something very dry, like a bit of moss, or a bit of wool and *what would you think would happen, if a spark fell on there? I was not trying to let a spark fall on there. What do you think might have happened?*
Child	It might have burnt.
Teacher	It might have burnt, *so it might have made, what?*
Child	A fire.
Teacher	It might have made a fire and that's exactly what happened.
	Case A: Excerpt 8.1

With Chin's (2007) suggestion in mind, that questions play an important role in determining the nature of science classroom interactions, I have opted to first examine the three questions (*italicised*) found within the above verbal exchange. The first two, were asked sequentially and have been classified as pseudo-open (lines 34-36), that is according to my revised version of Wragg and Brown's (2001) taxonomy of questions (see appendix 5.G). These two pseudo-open questions were followed by a closed question (line 39) which cued the students to work out the answer from clues provided (*ibid*). This funneling of questions, from pseudo-open to closed (Brown and Edmondson, 1984) narrowed the children down to a specific answer (line 40) and could be indicative of a teacher who knows the specific response they are looking for (Hardman, 2008). The focus on the pre-determined (or perceivable correct) answer through funnelling depicts an interaction which is predisposed toward Bird's (2011) letter of AfL, not the spirit, because the teacher is maintaining the control of the activity whilst the children recite the answer, as per her request. This type of talk, between teacher and child, is depicted as operating predominantly in a single direction (teacher to child) and has been indicated on table 8.1 below as Alexander's (2008) recitation. That is not to say that there was no cognitive involvement on the part of the child during these exchanges (Bird, 2011) but by using recitation to elicit a specific answer without further consultation, there was little opportunity for sharing the subsequent answers across the groups collective critical thinking's, to reify creativity-in-learning.

It is now that I turn to a comment I made in chapter 7, when reflecting upon the above verbal exchange in section 7.5. I stated that, to generalise from one moment as being indicative of the entire lesson is unfair; thus further interactions between teacher and pupil(s) need to be considered. To this end I have offered four more excerpts on case A's events maps for consideration (see figure 7.11b) and these are examined in further depth below.

8.2.2 The tinder box

The second interaction being examined takes place in minutes 30-31. During this time period, according to figure 7.11a, (the events map) the teacher demonstrates how to use a tinder box. As part of this activity the teacher invites the children to listen to her story and respond to her questions.

Teacher	[…The teacher demonstrated how to light a candle using a tinder box…] Soon I have a lovely fire in your pot and then I could put the candle in and light the candle, put it back there and now I’ve got a pot full of fire. How can I put it out? I don’t need the fire anymore I’ve lit my candle. What do you think?
Child	Um, you could get some water and put it on it.
Teacher	I could, I could pour water on to it, couldn’t I, but um…. All my lovely dry things would be wet and maybe I want to make another fire in five minutes time and everything would be wet. So putting water on it would work but then I couldn’t use it again. What else could I do?
Child	Um.. You could blow it.
Teacher	I could blow it out [pretends to blow out the pot of fire, the children laugh]. What would happen to that fire if I blew it out? What would happen to it?
Child	Um. It would… [teacher talks over child]
Teacher	I would blow out the fire wouldn’t I and I would blow out the fire perhaps onto something dry and then I’d start a fire. So I don’t want to put water on it and I don’t want to blow it out. Have a look at the things [on the table] that I’ve still got. How could I put out that fire? What do you think?
Child	Do you push the metal down onto it?
Teacher	Take the little lid and push it down onto the fire and it goes right into the bottom. And what does that do to the fire?
Child:	Stops it from um...lighting anything else.
Teacher:	Why does it stop it from lighting? Why does it make the fire go out? What does fire need in order to burn? Something that you’re breathing.
Child:	Oxygen
	Case A: Excerpt 8.2

Within the above exchange the teacher invited the children to express and share ideas relating to how they think she could put out an imagined fire, which was contained in a tinder box (see lines 312-314). The answers provided, such as, the pouring of water (line 315) and blowing it out (line 320) were brief but the teacher reinforced interest by elaborating upon why the child’s answer was incorrect (Wragg and Brown, 2001). Whilst this highlighted the teacher’s ability to be reflectively creative, the children were not subsequently involved within this evaluative verbal exchange and thus their opportunity to develop their own creativity was constrained. Nevertheless, there is an exchange of ideas with a view to solve a problem (i.e. the teacher invited the children to reflect further, about other ways of putting out the fire), some may argue that this could be interpreted as discussion (Alexander, 2008), but I would dispute this because the children’s attention was directed towards items displayed on the table (lines 327-328). After the students looked at the scissors, the candle snuffer and the metal lid, the teacher was able to direct them towards a specific answer (Hardman, 2008) through prompts and observational cuing (Wragg and Brown, 2001), see lines 327-335. Consequently I have interpreted this as being akin to Alexander’s (2008) recitation. With the teacher-led reflectivity plus the lack of child-led evaluative thinking I have reasoned that the teacher was assuming that the knowledge was being tacitly internalised by her students an apt description of Bird’s (2011) letter of AfL.

The third excerpt from case A below involves a scripted re-enactment of Florence Nightingale, performed by the teacher, when she tended to the soldiers from the Crimean war. This form of creative story-telling, McCullagh *et al* (2010) states, could put the child at ease and has the potential to stimulate interest and child-led dialogue.

8.2.3 Florence Nightingale

It is reported through the events map at minutes 58-59 (see figure 7.11a) that prior to excerpt 8.3 the teacher had invited three children to lie down on the floor and imagine they were wounded soldiers from the Crimean war. The extract below (8.3) depicts what happened verbally after this set of teacher-directed instructions.

	[3 children lay down on the floor and pretend to be wounded soldiers, whilst the teacher walks around them holding a Nightingale lamp]
Teacher	they were all getting better and do you know; every night Florence came round with her lantern and she said ‘good night’ to every one of those injured soldiers and she came round to them she said [children laugh] she said ‘good night, have a good night sleep, so glad you’re feeling better. Has somebody written to your mother to tell her that you’re getting better? [laughter] Are you sure you had enough to eat today? [laughter] And she said good night to them, right. Stand up and go back to your places and, can you all sit down. They called her the lady with the lamp, Florence Nightingale and this is the sort of lamp that Florence Nightingale would have carried as she went around the hospital and looked after the people and so many of the soldiers were made better

Case A: Excerpt 8.3

The participation of the children (i.e. the capturing of their interest) could be arguably reported as apparent through their laughter (see lines 634 and 638). This provides support to Bird’s (2011) claim, that all forms of interactions in the classroom, including those that do not directly involve verbal interactions can engage children. However, Dorion (2009) suggested that active participation (on the part of the learner) could only occur in drama when sympathising with the emotions of others. With the verbal exchange, in the extract above, being in a singular direction (see table 8.1), because the teacher was either imparting information through her story, or telling the students what to do, I have interpreted this interaction to be aligned with Alexander’s (2008) instructional talk. This kind of linear teacher to child interaction makes it impossible to illuminate if the children were in actuality, empathising with the wounded soldiers or appreciating Florence Nightingale’s (the teacher’s) endeavours to tend to her patients. Thus the children’s personalised creative efforts or their actual learning (i.e. the letter or spirit of AfL) remained hidden. To check that the learners were capable of reciting this information the teacher could have accommodated Alexander’s

(2008) recitation talk. It is this form of interaction that was interpreted as taking place in both excerpts 8.1 and 8.2 (sections 8.2.1 and 8.2.2 respectively) and, I believe can also be found in 8.4 below.

8.2.4 Electricity

Excerpt 8.4 below provides the transcript from a period of time (minute 76) where the teacher, according the case A's events map (figure 7.11a), demonstrates a recognisable everyday item (a torch).

Teacher	Electricity and we use electricity to light our homes and that means you can see to read until late at night and you don't have to have candles and oil lamps and if you go out at night you might carry one of these with you [holds a torch and clicks it on and off and the children gasp]. *What have I got here?* Yes.
Child	Torch.
Teacher	A torch. *What's the power that makes the torch light up?*
Child	Battery.
Teacher	Batteries, yes, there's batteries inside here. There's a power inside the battery. *What the power that's inside the battery?*
Child	Electricity
	Case A: Excerpt 8.4

Upon examination of the above interaction an extension of three teacher-child observational and recall questions (*italicised*) were revealed (Brown and Edmondson, 1984). Each question has arguably been designed to act as a prompt to direct the students to a specific answer (Wragg and Brown, 2001). This is a prime example of Alexander's (2008) recitation, similar to excerpt 8.1, whereby the children's prior knowledge is recognised but only to guide the children to a predefined outcome (Hardman, 2008). As such it resonates with Bird's (2011) definition of the letter of AfL and the children's subjective creativity is not being elucidated.

Nearing the end of the science lesson there was a 13 minute demonstration of an unusual Christmas candle where the verbal interactions appeared more open. This is instead of the predominant focus being on the teacher's requests of the children to recite a predefined answer. The verbal exchange chosen to exemplify this activity, in order to elucidate the nature of talk available during the teacher-child interactions has already been discussed in the methodology chapter (section 5.6.2.3, excerpt 5.1), but this was only referred to in chapter 5 to explain my reasoning for choosing to look beyond analysing the types of questions being asked and not to reify any potential creativity-in-learning or embedded formative assessment, as is my intention below.

8.2.5 An unusual Christmas candle

In excerpt 5.1 I highlighted how a child expressed an anthropomorphic notion. That is, the wooden dolls on an unusual Christmas candle had somehow come alive and were, by some means, rotating the candle's platform. This is not presented on excerpt 8.5 below, which takes places in minutes 82-84 but what is depicted here is the teacher's response that comes directly after the child had expressed this imaginative idea.

Teacher	No, because there just staying still, they're going round; it's really there….top that's going round. (.) *What do [you] think is happening?*
Child	Um.. The thing at the top [the blades/paddles of the rotor] is making it go round.
Teacher	Well the thing at the top is going round and that's making all these things go round, but why, *why is that happening?*
Child	Is it because all of the air off the candles makes the top spin and ( ) [the teacher talks over the top of the child].
Teacher	The air off the candles makes it go round, he's right, but why does the air off the candles make it go round? What do think is going up there? If I come here what would I feel? (.) [places hand just below the rotor] Oh.(.) What would I feel? Yes, at the back.
Child	Heat
Teacher	Heat, hot (heat) [cough], it's hot, it's hot air, hot air rises and when I put my hand here I can feel how hot it is and the hot air is coming up, it's hitting against these little paddles and it's making them turn round, as it comes up and goes through. So it's hot air that's doing it. If I make them
	Case A: Excerpt 8.5

According to Wragg and Brown (2001) open questions are asked in order to enable the person/people providing the answers the opportunity to proffer a wide range of responses and the two open questions asked by the teacher in excerpt 8.5 (*italicised)* afforded this opportunity. The expression of their subjective reasoning, through responding to these open questions, was an attempt by the participants to solve the issue at hand. However, instead of taking a risk and challenging the children to reflect upon their answers to illuminate their on-going learning, the teacher appeared to guide the children through prompts and cues. A similar finding to the previous excerpts examined (see lines 808-809, 812-813 and 816-819). Thus the learners' independent agency through critical reflection is left unexpressed and Bird's (2011) spirit of AfL is not developed. Furthermore, as I stated in section 8.2.1, because there is limited consultation between student and teacher, due to the directive nature of the questioning, the opportunities to express subjective creativity became somewhat limited. Whilst this description appears akin to my interpretation of excerpts 8.1, 8.2 and 8.4 the teacher, I believe, is this time not communicating through recitation (Alexander, 2008) for there is an unidirectional exchange of ideas between the teacher and pupils, plus the students' responses are fuller explanations compared to the brief answers previously proffered. Additionally there is also a constructed outcome at the end. According to my literature review (2.2-B.1.1.2), this would resonate with Littleton and Mercer's (2013:1) definition of 'interthinking', where '[people] think creatively and productively together'. Thus with table 2.1 in mind, the talk made available at this point in time is similar to 'cumulative discussion'.

8.2.6 Summarising the nature of teacher-child dialogue in case A

Having examined all five excerpts above from case A (see 8.2.1-8.2.5), through my newly conceptualised framework (see 2.2-B.1.1.2), table 8.1 below depicts my findings in an illustrated summarised form.

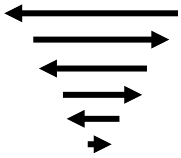
Excerpt number	**Minutes in which excerpt takes place**	**Associated picture** *(Ties each excerpt to case A's events maps, see figure 7.11a-b)*	**Nature of talk observed in the excerpt**	**Diagrammatic representations of the direction and extent of verbal exchanges**
8.1	2-3		Recitation (Alexander, 2008)	
8.2	29-31		Recitation (Alexander, 2008)	
8.3	58-59		Instruction (Alexander, 2008)	
8.4	79		Recitation (Alexander, 2008)	
8.5	82-84		Discussion (Alexander, 2008)	

Table 8. 1: Five excerpts, from case A, depicted as diagrammatic representations

Table 8.1 illustrates the nature of talk taking place in case A, both in its written form and pictorially (see fourth and fifth column) during specific periods of time (second column). It also, through photographs, displays the unusual objects the teacher employed to pique the children's interest, whilst she imaginatively recounted the tales of historical figures (third column). These pictures tie each of the excerpts to case A's events maps (figure 7.11a-b) displayed in chapter 7*.* This method of displaying the data will be duplicated for cases B and C.

The first four excerpts were depicted as consisting of patterns of talk which Alexander (2008) described as being conveyed mainly in one direction (from teacher to pupil). This linear approach was epitomised in excerpt 8.3 through the way in which the teacher recounted the tale of Florence Nightingale tending to the wounded soldiers. Within the other excerpts (8.1, 8.2 and 8.4) the children's voice was acknowledged but as a means to guide the students towards a sought after answer, through Alexander's (2008) recitation. The final excerpt however (8.5), was interpreted as being 'cumulative discussion', which according to my literature review (2.2-B.1.1.2) would entail participants sharing ideas in an attempt to understand each other's perspectives through interthinking (Littleton and Mercer, 2009).

Reflecting on the above summary, I found it interesting that this verbal exchange was achieved despite child-agency and risk-taking being interpreted as absent in the previous chapter (see figures 7.2a-c and 7.5a-c in chapter 7). I had also, in chapter 7, found it fascinating that these interactions were mostly interpreted as occurring (through figure 7.8a), when the teacher conveyed curricular content and monitored factual knowing or recall of subject matter. Whilst the title of this category aptly resonates with Alexander's (2008) description of recitation (see literature review, section 2.2-B.1.1.2), it also highlights the possibility of child participation through Sfard's (1998) knowing, which I have previously associated with the spirit of AfL (see section 8.1) but I could not demonstrate this level of participation (or personalised on-going development of learning) in any of the five excerpts, so how is this possible? I refer back to Bird (2011) at this point because it was he who suggested that just because the classroom interactions were, in the main, teacher-led it did not mean there would not be any intrapersonal involvement on the part of the child, but how much engagement can be illuminated through the exchanges examined above is problematical, especially when the classroom interaction was interpreted as focusing mainly on the teachers own performance, or via the acquisition of tacit knowledge, through recitation. This, according to Bird (2011), will only illuminate the letter of AfL and perhaps this is why the learners developing knowing (or the spirit of AfL) did not emerge from within the transcripts.

Having revealed the guidance offered by the teacher to the children, in case A, had a tendency to be teacher orientated my attention is now turned to case B.

8.3 Examining verbal exchanges from case B through five excerpts

Here the teacher employed dramatic techniques (McGregor and Precious, 2015), as described and illustrated on case B's events map (see figure 7.12a, section 7.7.2 in the previous chapter). I begin my examination of case B with an excerpt that depicts the teachers desire to transport the pupils to the rainforest through an unusual means.

8.3.1 The magic carpet ride

To place the excerpt I am about to examine into context I will set the preceding scene, this description is taken from the account given in section 7.3, in the previous chapter. Initially the teacher arranged the pupils on a magic carpet (a rug placed on the floor). Once organised she invited her students to empathise with flying to their destination whilst asking them to describe what they anticipated they might observe over the edge of their unusual transport. What follows is part of the transcript, taken from minute 7, when the children are asked to share what they thought they might see below as they flew across the Sahara Desert.

Teacher:	We're just going over the desert, what will you see? Shhh. J.
Child:	Sand.
Teacher:	You might see sand. What animals might you see in the desert, do you think?
Child:	Lizards (will), what you see in the desert.
Child:	Snakes
Teacher:	You might, but not from really high unless it was a massive snake.
	Case B: Excerpt 8.6

To engage the children with the activity the teacher invited them to imagine what they might see beneath them in the desert (lines 115-116 and 120). Three responses are offered, they were: *'sand'* (line 117), *'lizards'* (line 120) and *'snakes'* (line 121). Whilst the question may appear open, for a wide range of ideas could be potentially proffered, the responses provided by the children were brief, thus the question was in reality classified as pseudo-open (Wragg and Brown, 2001). Despite the tapered nature of the answers I cannot deny that the teacher appeared to readily acknowledge any ideas (line 118 and 122) and she even went on to elaborate upon them reflectively (line 122) which, according to Wragg and Brown (2001), is an important way to convey interest to the children. This is despite the questions only stimulating the recall of known desert inhabitants through Alexanders (2008) recitation. However, it was the teacher critically reflecting upon the responses, thus the learners' independent evaluative thoughts were unarticulated, and neither the critico-creative practices which reify exploratory exchanges (or my depiction of creativity-in-learning) nor the child's agency within the developing learning, i.e. Bird's (2011) spirit of AfL, could be illustrated.

To actively *involve* children in learning science, instead of just piquing interest, McGregor and Precious (2010) suggested providing the pupils with opportunities to discern the characteristics and qualities of a scientist. This, they believed, could be achieved through ‘hot-seating’, where ‘the teacher [or adult] is placed in an “expert” role and students pose constructive questions’ post monologue (*ibid*:57). The following excerpt depicts just such a session.

8.3.2 Being Marianne North

The excerpt below (8.7) takes place between minutes 19-20. The TA, according to the events map (figure 7.12a) had previously performed a Marianne North monologue (McGregor and Precious, 2015:209-210) and had now been placed into the ‘hot seat’.

Child:	Why ( ). Why you doing it?
TA:	Why am I painting? Because I want people to see things that I can see when I go on my travels. I want to show people parts of the world and what I can see there. Yes.
Child:	You travel around the world
TA:	Yes, I’ve travelled to lots of places.
Child:	How did you get here?
TA:	How did I get here? I walked.
Children:	What!
Teacher:	Sailed.
TA:	Wait, how did I get where? To where I am now or to the rainforests. How do you think I travelled to the rainforest? When Queen Victoria was alive.
Child:	(.) On a donkey.
TA:	I’d used a donkey to get up the mountains, I have.
Child:	A carriage.
TA:	I’d used a carriage to where I’d.. My main way of transport. I did use a carriage to get there. How did I get here?
Child:	Was it a boat?
TA:	A boat. (I would have gone by boat). Yes.
Child:	Why are you going to different places?
TA:	Why am I going to different places? Because the things I see far, far away in my travels, we don’t see ( ) the beauties, the colours, the plants.

Case B: Excerpt 8.7

It is useful to refer back to the previous chapter and my graphical representations of the original observation when examining this verbal interaction, (see section 7.4). This is because it represents an activity (i.e. hot-seating) that was subsequently interpreted as being both TC and T4C through my observational schema (table 5.4, methodology chapter 5.6.2.4), but only through the third category where the teacher’s intention was to invite the children to evaluate their own performances/ideas (see figures 7.3c, 7.6c and 7.9c in the previous chapter). To briefly reiterate I will refer to the third categories descriptors (the second column on table 5.4), where I systematically characterised the teacher’s actions. By reflecting upon these descriptions I can see that I have construed the teacher’s practice as being TC when the teacher asks the children to be reflective through the task at hand or T4C when they ask the children to be creative and/or critical. This however, has highlighted two issues relating to my interpretation of excerpt 8.7 through table 5.4. They were:

1) That I have interpreted both TC and T4C as taking place when the children, not the teacher, were independently challenging Marianne North (the TA). The schema should be representing the teacher's actions only and
2) As a consequence of examining the above excerpt I acknowledge that the way in which I originally interpreted/described my descriptors of TC and T4C through my observational framework did not go far enough to illuminate the reciprocal teacher-child dialogue which reflects Fisher's (2001) critico-creative practices. That is, I have only sought an example of creative talk and not looked for a critical exchange of ideas, and according to my literature review (section 2.2-B.1.1.2) creativity-in-learning requires iterations of both.

I have now recognised that the verbal exchanges taking place in excerpt 8.7 were freely (and creatively) articulated by both TA and children but they were not critically evaluated, and this accommodates Alexander's (2008) discussion and not exploratory dialogue. This, according to my analytical framework, will not illuminate creativity-in-learning. By giving the above further consideration, I have also realised that the observational schema should characterise the teacher's actions, not the pupils'. With this in mind, perhaps the teacher's intentions for this third evaluative category, on table 5.4, should read: '*the teacher critically and creatively reflects upon the pupils' ideas',* this representing TC and, *'the teacher invites the children to critically and creatively reflect upon (their or others) ideas and performances',* this illustrating T4C. Thus the focus of these newly conceptualised descriptors is the teacher's practice and now resonates with Davies's (2011:114) description of creative teaching (see literature review section 2.2-B.2).

I have also found it fascinating when considering a previous conjecture put forward in chapter 7, that is, that this part of the lesson may reify the pupil's ZPD (see sections 7.3 and 7.4). This mediatory practice, I had proposed, required both learner autonomy (through the teacher's encouragement) and the teacher's risk-taking behaviour (i.e. the challenging of the children's ideas) and both had been illustrated as occurring through case B's graphical representations (see figures 7.3 and 7.6). However, upon inspecting excerpt 8.7 it becomes obvious that it was the children challenging the TA through questioning (see lines 329, 335, and 349) and therefore it is their risk-taking behaviours that have been interpreted and been illustrated on figures 7.6a-c, not the teacher's, thus changing the observational schema to reflect the teacher's actions is paramount. I could go on to claim that this level of self-sufficiency (or independent agency) being displayed by the children could potentially illuminate the spirit of AfL, according to Bird's (2011) description (see section 8.1), but without the teacher's interventions (i.e. the challenges from the more experienced other) which I have previously construed, in chapter 7, as being critical in enabling the verbal articulation of the child's participatory learning (Sfard, 1998), the spirit of AfL could not be verbally conveyed.

The dramatic techniques (hot-seating post monologue) provided an example of a social exchange taking place between the children and the TA. The following excerpt (8.8) was chosen because the pupils interacted with one another after reflecting upon their peers' physical actions. I thought this would be interesting because, as Glăveanu (2011) stated, these strategies, based around drama, should enable the children to interact through both physical and social means.

8.3.3 Traversing the layers of the rainforest

The verbal exchange taking place below contains the transcript pertaining to a question and answer session which occurred following a 'freeze frame' activity (in minute 29), as described in the previous chapter (section 7.7.2). Preceding this excerpt, according to the events map (figure 7.12a) the teacher had invited a group of children to enact the physical movements required to move between the different layers of the rainforest canopy. The remaining pupils were asked to observe their classmates' enactments and think of questions to ask their peers. I have interpreted this activity as being representative of the teacher encouraging independent thinking because the loci of control appeared to be handed over to the learner (this encouragement of pupil autonomy is reflected through figures 7.3a-c, in the previous chapter, see section 7.4). To illuminate any risk-taking behaviour by the teacher (i.e. if there were any appropriate challenges made) I will need to examine the excerpt itself.

Teacher:	Okay, freeze. Has anybody got a question for one of the children? W.
Child:	J. why are you walking along like that?
	[Children laugh]
Teacher:	So why were you doing that, what were you doing? You were…
Child:	(Thinking)
Teacher:	You were thinking and looking closely. Lovely. A.
Child:	Why was R. doing massive steps?
Child:	Because if, if I steps on flowers it would ruin the flowers [teacher talks over child]
Teacher:	So you were being careful. Is there another reason you might be, um, taking big steps like that? S.
Child:	So you don't get prickled.
Teacher:	So you don't get prickled by things

Case B: Excerpt 8.8

Whilst there appeared to be risk-taking, illustrated here through children questioning each other, as described by Warwick and Davies (2013), because the children were willing to ask questions and express their own subjective ideas, this does not reflect my interpretation of the teacher's risk-taking behaviour which involves the practitioner challenging the children's ideas, so this does not quite extend from cumulative into exploratory talk (Mercer, 2008). However, the teacher followed the children's seemingly independent questioning with, what Brown and Edmondson (1984) called, a speculative creative question (lines 481-482) and this is illustrative of challenging the pupil to proffer further ideas (McCallum *et al,* 2000). Following this the child offered a different response to that of her first reply (line 483) providing confirmation that this type of open question could provide a range of different imagined ideas. This, I propose, was an example of the pupil expanding upon an idea and demonstrating their understanding of the forest floor further and thus I can argue that this is an apt example of Davies's (2011) T4C because the focus was on the learner's creative imaginings.

Having now stated that this excerpt illustrates limited risk-taking I have to admit that it does not provide the full context. Prior to the child-led question and answer session the teacher guided the pupils towards the type of inquiry that should be addressed, she stated, *'you're [the pupils on the rug in the centre of the floor] going to start walking through [the rainforest floor] and we're [everyone not on the rug] going to stop them and ask how, why they're moving like they're moving. So if you've got a question for them think of your question'* (lines 468-470). Thus, upon reflection, perhaps it was no surprise that the two questions asked, by the children, were connected to the way in which their peers chose to move (see lines 473 and 478), that is, the children appeared to be following the teacher's initial set of instructions. Despite the teacher's directions this still reflects Jeffrey and Craft's (2004) notion, when they suggest that TC (an imaginative activity being led by the teacher) is intimately linked with

T4C (i.e. it is child focused). Excerpt 8.8, together with lines 468-470 (as *italicised* above), certainly provided an indication of this transition occurring sequentially (Craft, 2005). For the teacher initiated this creative episode and then subsequently directed the children to ask a similar kind of speculative (evaluative) question of their peer. Referring back to figures 7.3c, 7.6c and 7.9c, in the previous chapter this is possibly how T4C became discernible (i.e. through the teacher's directions).

It is undeniable that the back and forth exchange of ideas, through the questions asked by the pupils, as directed by the teacher, enabled the creative imaginings from the rainforest floor to be verbally expressed by the children. However, these thoughts were gathered and considered but not reciprocally critically challenged (apart from one speculative question, lines 481-482). This according to my model of the available types of talk in the classroom (table 2.1) would therefore be interpreted as discussion, but because there was no overall consensus formed I could not construe interthinking (Littleton and Mercer, 2013). This is illustrated on table 8.2 as an unconnected set of similarly sized, antiparallel arrows. I am not stating that no learning took place on an intrapersonal level, just that the way in which the teacher encouraged autonomy by directing the pupils' thinking (by suggesting the question to ask their peers) did not illuminate the child's (or children's) developing understanding (or the spirit of AfL). Had the children been invited by the teacher to justify their responses, as Gillies *et al* (2014) suggested they should, then this could have also provided an opportunity for the critico-creative practices of creativity-in-learning to be demonstrated through exploratory dialogue.

Having now started to respond to the questions posed during chapter 7 (section 7.4), which concerned the transitions between TC and T4C (during minutes 17-40), and having gained an insight into whether the children were, in actuality, independent of the teacher, I now turn to something else I had previously thought would be interesting to do (see section 7.6): that is, to compare the exchanges taking place between minutes 17-40 to the verbal interactions during the second half of the science lesson, where no autonomy or risk-taking was interpreted as being reported. I felt this comparison would illuminate whether independent learning and the challenging of subjective ideas were needed to reify the child's developing learning (their ZPD). However, due to the realisation that it was the children's risk-taking behaviour I was interpreting, not the teacher's, and then subsequently noting the teacher's directive guidance limiting the learners' independent agency, I have to acknowledge that the mediatory practice required to illuminate the ZPD, as described in section 7.4, has not been discernible. Thus this comparison would no longer be directly possible. Nevertheless it would still be interesting to contrast the final two excerpts, as depicted on figure 7.12b, because, according to the events map (figure 7.12a), the first excerpt is from part of the lesson which is described as being teacher-directed, whilst the second is portrayed as being part of the lesson which is teacher independent. This latter excerpt is especially interesting because it is in direct contradiction to how the teacher's practice is represented on the graphical representations of their science lessons (see figures 7.3a-c), i.e. no independence (encouragement of autonomy) was illustrated during its specified time period.

8.3.4 Observing an unusual plant

The events map (figures 7.22a and 7.22b) depicts excerpt 8.9 (which occurred during minute 52) as taking place when the teacher enquires, of half the class, (for the other half is in another room) how they would describe a plant to their absent classmates.

Teacher:	Can you think of an animal that might have something on it like that sort of shape? [the teacher points to a leaf]
Child:	A frog.
Teacher:	No, I don't think the leaves look much like a frog.
Child:	A wing.
Teacher:	Oh, a bit like a wing, yeah.
Child:	Iguana, they have like tails that curve up.
Teacher:	Well they do but this doesn't look anything like an iguana's tail, so you've got to think about, it looks a bit like the shape of a rabbit's ear, would you say, those leaves.
	Case B: Excerpt 8.9

The initial question asked by the teacher (lines 749-750) is, according to Brown and Edmondson (1984), speculative. This, Wragg and Brown (2001) state, could allow for wide ranging answers to be proffered; in this case three individual and creative responses were presented (see lines 751, 753 and 755). These subjective responses were acknowledged, reflected and even expanded upon, albeit briefly, by the teacher, through 'yes', 'no' exchanges. Mercer (2008) might advise that this is representative of disputational talk, which is indicative of a limited interaction, but Wragg and Brown (2001) suggests that this is how a teacher typically conveys interest. I believe this is an attempt to pool together a number of creative ideas, to solve a problem, (that is, what the leaf, according to the children's anthropomorphic imagination, looked like), although no answer was critically discussed or perceived as being a good metaphor or simile to describe it. With this in mind, I have interpreted this excerpt as a cumulative interaction (Mercer, 2008) which, according to table 2.1, is more in line with Alexanders (2008) discussion, thus it is a cumulative discussion but without a consensus opinion being formed. This is illustrated on table 8.2 as a set of unidirectional similarly size arrows.

Following on from examining the pitcher plant the whole class was brought back together to draw the unusual plant, reportedly independently of the teacher, using only the verbal descriptions. Excerpt 8.10 below, provides a small excerpt of the teacher-child interactions from this activity

8.3.5 Sketching the unusual plant

The activity (drawing the plant), according to the events map, minutes 60-70 (figure 7.12a) was initiated by the teacher. My interpretation of the map indicated that the teacher asked the pupils who had observed the pitcher plant originally to pair up with a child who had not. The child who had not seen the plant then drew the plant using only their peer’s verbal directions. That is, the children were construed as being able to work independently of the teacher. Excerpt 8.10 is part of a one minute interaction which took place six minutes into this activity. This will hopefully illuminate what was actually happening during this period of time.

Teacher:	[Teacher talks to the whole class] What shape did we say the leaf was like? A bit like a bit like a rabbit’s.
Children:	Ear.
Teacher:	Ear. What did it have down the middle of the leaf? There was a….
Child:	Long stick.
Teacher:	Line.
Child:	Line.
Teacher:	What came off the end of the leaf?
Child:	Like a little water bottle.

Case B: Excerpt 8.10

If excerpt 8.10 is compared to excerpt 8.9 the teacher’s perceived view of what the leaf looked like (a rabbit’s ear), and not the pupils’, is being re-enforced through repetition, or as illustrated on table 8.4, as Alexander’s (2008) recitation. Whilst I have not supplied the transcripts this recollection of previously encountered information is also true of the line down the center and the water bottle at the end of the leaf. This is an approach I have previously associated with expositional teaching (see 2.2-B.3.3) and highlights how a planned activity, which can be interpreted as an independent (autonomous) part of the lesson, as it is in the events map, can in actuality be guided via the teacher. The inconsistent findings between methods of analysis (i.e. the events map versus this theoretical framework being applied in this chapter) serves to highlight the need for further methods of analysis which can illuminate these sorts of discrepancies (Denzin and Lincoln, 1994).

8.3.6 Summarising the nature of five verbal exchanges examined in case B

The dramatic activities employed by the teacher, in case B, have been examined through five excerpts (in sections 8.3.1-8.3.5) and these have subsequently been visually depicted and summarised in table 8.4 below.

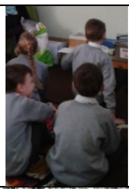
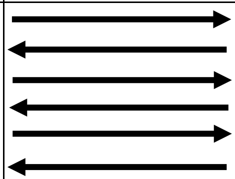
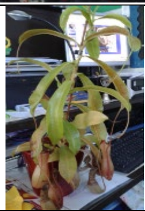
Excerpt number	**Minutes in which excerpt takes place**	**Associated picture** *(Ties each excerpt to case B's events maps, see figure 7.12a-b)*	**Nature of talk observed in the excerpt**	**Diagrammatic representations of the direction and extent of verbal exchanges**
8.6	7		Recitation (Alexander, 2008)	
8.7	19-20		Discussion (Alexander, 2008)	
8.8	29		Discussion (Alexander, 2008)	
8.9	52		Discussion (Alexander, 2008)	
8.10	66		Recitation (Alexander, 2008)	

Table 8. 2: Five excerpts from case B, depicted as diagrammatic representations

Interestingly two excerpts (8.6 and 8.10) depicted the teacher as readily acknowledging the children's ideas (alternative or not) and conveying interest through recitation. The types of questions found incorporated into these verbal interactions, to elucidate the children's subjective thoughts, focused on the 'right' ways of doing things (see excerpt 8.10) or on performance (such as naming the inhabitants of the Sahara desert, excerpt 8.6). The teacher, nevertheless, used the interaction as an opportunity to appreciate different perspectives (Wells and Arauz, 2006), and this is aptly illustrated through excerpts 8.7, 8.8 and 8.9, which are depicted on table 8.2 as Alexander's (2008) discussion. However, there is no final outcome construed within these three excerpts, hence why the arrows do not incrementally decrease or increase in size. To extend these verbal interactions further the shared ideas expressed could have been critically and mutually considered by all participants, this may have revealed an exploratory dialogue from which creativity-in-learning could have been reified. For example, in excerpt 8.7, when the TA was reasoning why the scientist travelled to foreign lands, the pupils, with help from their teacher, could have considered and explored the rationale behind Marianne's travels.

Through the examination of these five excerpts (sections 8.3.1-8.3.5) I have discerned how the teacher provided ample opportunities for the children to be imaginative and inventive, but when scrutinising the context in which the verbal exchanges were set further it was noted that what may have been initially construed as the pupils being independent was, in actuality, directed by the teacher (see sections 8.3.3 and 8.3.5). Because this interaction limited learner agency, which was an integral part of Bird's (2011) definition of the spirit of AfL, only the letter of AfL was revealed. I had also previously argued, in section 8.3.3, that the reification of the child's ZPD not only requires learner agency it also requires the incorporation of the teacher's risk-taking behaviour, for it is this challenging of the pupils' ideas that is the link between the pupils' unspoken developing knowing and the child's reflective learning being conveyed. This risk-taking behaviour was witnessed through the pupils questioning the Marianne North monologue (see section 8.3.2, excerpt 8.7) but note how this was not through the teacher's practices. This provided a pivotal moment, for I realised that the observational framework (table 5.4) did not reflect the teacher teaching in such a way as to enable critico-creative thinking to be verbally expressed through the children. I have recommended reviewing the descriptors for the teacher's actions on the observational framework for the third category (i.e. the evaluation of ideas) and upon further consideration the same revision of the first two categories (i.e. the teacher intentions) may also be required to ensure that the teacher's actions, not the pupils, are reflecting characteristics of expositional teaching, TC and T4C. I will give this further consideration in chapter 10 of this thesis (section 10.2.2).

8.4 Clarifying teacher-child verbal exchanges taking place in case C through five excerpts

In chapter 7, section 7.3, it was noted that the teacher, from case C, deviated from Wood (1992) and Dillon's (1994) descriptions of a normal questioning style. That is, most of the questions the children were invited to answer were open, as opposed to those in cases A and B which were closed and constrained their responses. In contrast the questions presented by case C were open-ended, that is, they invited a significantly wider range of unfettered responses. The type of activities exemplified in case C also invited learners to suggest their own ideas (that is engage in cognitive processing) and demonstrate higher order thinking skills (Hanley *et al,* 2015), this would reportedly promote analysis, synthesis and evaluation (Collins, 2014). Presseisen (2001:48) suggests how Bloom associated these three thinking skills with different facets of behaviour. These have been categorised and described below:

- Analysis is – connecting, relating, differentiating, classifying, arranging, checking, grouping, distinguishing, organising, categorising, detecting, comparing and inferring (*ibid*);
- Synthesis is – producing, proposing, designing, planning, combining, formulating, composing, hypothesising and constructing (ibid) and finally;
- Evaluation is – appraising, judging, criticising and deciding (*ibid*).

Bloom assigned levels of difficulty to each of these thinking skills, proposing that evaluation was more demanding than synthesis, and synthesis was more challenging than analysis (*ibid*). However, Sternberg (2003:82) did not view these skills as hierarchically related because he considered analysis and evaluation as more closely related (requiring critical appraisal) rather than synthetic thinking which is concerned with connecting and relating things, according to Bloom. Marzano (2001:181) challenged the hierarchical structure further when he stated: 'any attempt to design a taxonomy based on difficulty of mental processing is doomed to failure. This is because of the well-established principle in psychology that even the most complex process can be learned to a level at which it is performed with little or no conscious effort'. The inherent difficulty Bloom suggests through his hierarchical taxonomy is thus in dispute. Arguably in different contexts (Bruner 1996) all six processes of Bloom's taxonomy (knowledge, comprehension, application, analysis, synthesis and evaluation) could be challenging.

The cognitive processes of analysis, synthesis and evaluation are each challenging in many contexts, thus I intend, through the examination of case C's five excerpts, to discern whether these particular higher order thinking skills were made explicit. This will be discussed in case C's summary (section 8.4.6). During the section-by-section examination (sections 8.4.1-8.4.5), I will continue to consider whether exploratory dialogue was illustrated and how (or if) this effected the reification of both creativity-in-learning and the spirit (rather than letter) of AfL.

8.4.1 How do I know I'm alive?

The first excerpt (8.11) I examine comes from the seventh minute of the lesson, from an activity called 'The Big Question'. The question being considered by the students' is, 'How do I know I'm alive?'. It is interesting to note that on the events map (figure 7.13a) this activity illustrates the children sharing their original ideas with the whole class, whilst the teacher was depicted as being subsequently both critical and creative whilst considering the pupils responses.

Teacher	E. How do I know I'm alive?
Child:	Senses, so like you can feel things, you can see things, you can touch things and taste things.
Teacher:	Okay, I'm going to ask you back the same question. Does a tree touch things, taste things, see things, hear things? But a tree is alive. I'm going to leave you with that thought. W.
Child:	You're breathing.
Teacher:	Okay. (.) Do all living things breathe? I know you breathe, but if I was to extend the question how do I know I'm alive, if I'm a tree is breathing going to be one of the things makes me know I'm alive?
	Case C: Excerpt 8.11

This small excerpt is a sub-set of a larger extract of transcript that I offered up in the previous chapter (excerpt 7.1, appendix 7.A). I had earlier stated that it illustrated how different children proffered no less than eight distinct ideas (see chapter 7, section 7.3) and my analysis indicated that the teacher either paraphrased or elaborated upon the pupils independently verbalised thoughts. The two responses offered in excerpt 8.1 above (lines 65-67 and 69-71), fell into this latter category of elaboration because the teacher converted them into a reflective question (Wragg and Brown, 2001). I proceeded to interpret this as the teacher adopting risk-taking behaviour because she was encouraging and challenging the children to see things afresh. However, this critical engagement, on the part of the teacher through exploratory probing (Littleton and Mercer, 2013; Alexander, 2008) was not reciprocated by the pupils. I suggest that this separates the children's intrapersonal learning, i.e. their mini-c, as described by Beghetto and Kaufmann (2007), (described further in chapter 4) from the more experienced other (the teacher) and this in turn leaves the child's ZPD (i.e. their ongoing learning) unarticulated. That is not to say that there is not any participation on the part of the learner (Bird, 2011) just that this particular verbal exchange omits the vocalisation of the iterative process involved in creativity-in-learning (as proposed through my theorised model, chapter 4, figure 4.1). Thus the focus of the exchanges taking place in excerpt 8.11 is on the exposure of the children's initial individual and unique ideas (represented on table 8.3 as a small arrow) and the teacher's reflective performance (illustrated as an incomplete circle which does not fully traverse the complete 360^0 diameter). This does resonate however, with my definition of encouraging autonomy because the teacher actively encourages and welcomes diverse notions; and this independence is echoed within Bird's (2011) definition of the spirit of AfL. However, because the final focus of the interaction is on the teacher's critical questioning rather than what is, or has been, learnt by (or through) the child the spirit of AfL is ultimately left wanting.

Besides 'the big question' activity there are a number of other ways to challenge children cognitively, this is according to the Holligan and Wilson (2015). However, the following activity employed by the teacher, i.e. 'alive versus not alive', is not specifically mentioned as being one of them, but it has been endorsed by Wilson *et al* (2017) as a higher order thinking strategy.

8.4.2 Alive versus not alive

By examining the events map (figure 7.13a) during this activity the children were provided with a worksheet which contained 21 nouns (these are represented on a photograph on table 8.6). The teacher requested that the pupils', in small groups (2-4 pupils), place these 21 items into two separate columns entitled 'alive' and 'not alive'. I have chosen to examine a two minute excerpt (minutes 17 and 18) from the whole class plenary at the end of this activity because it focuses on the interactions between the teacher and child (i.e. both illocutionary and perlocutionary acts are evident).

Teacher:	[Teacher laughs] Nice. Okay, A. tell me something that you've got in your not alive column that you aren't totally sure about or are you really convince that everything in that column you're right on.
Child:	Well, we put jumper not alive
Teacher:	Jumper.
Child:	but, um, (I thought) add ( ) with things, keep away and create glasses and they ( ) sheep which has an arrow pointing, saying jumper. Wool for the jumper is like ( )
Teacher:	Ah, I see what you're saying. So this is what we were talking about over here [points to a group children], the jumpers made of wool, wool comes from a sheep, sheep are alive, therefore does that mean the wool is alive?
Children:	No [children start talking to each other]
Teacher:	Ah, hands up if you've got something to say. J.
Child:	Well, um, (sorry) to hair. Um.
Teacher:	Right, R. listen.
Child:	It's like hair and hair is alive but the bits on the outside of the hair go dead. That's why it doesn't hurt so much when you, um, have a haircut and if you pull your hair it will hurt because you're pulling out the roots and the live bit as well.
Teacher:	And is that the same therefore with sheep's wool?
Child:	I guess so.
Teacher:	Don't know, I honestly don't know. Er, E. and H. was there one on there that you were a bit iffy about?
	Case C: Excerpt 8.12

The pupils' responses to this activity were freely given and appeared readily accepted as adequate notions worthy of further consideration. This transpired because the manner in which the teacher made the original enquiry set an expectation that there was no correct or incorrect answer (see lines 224-226) and thus the naming of any of the 21 items originally listed was acceptable (McGregor, 2007:253). The teacher's subsequent reflection upon the child's uncertainty (lines 232-235) implied interest (Wragg and Brown, 2001). However, I recognise that this articulated consideration, was also her interpretation of what the child was originally thinking (lines 229-231) and it is possible that she could have miss-interpreted the child's subjective idea. This elaboration was then subsequently constrained by the asking of a closed question (lines 234-235). Nevertheless this, according to Davies (2011:15), could have provided the stimulus for the further speculation verbalised by another child (lines 239-244). I could suggest that this aptly illustrates Jeffrey and Craft's (2004) notion that the 'learners [were] model[ing] themselves on their teacher's approach' (*ibid*:85) and therefore the pupils are being independently creative through the way the teacher invited them to generate their original propositions.

With the gathering of innovative ideas in mind I have interpreted this excerpt as accommodating Mercer's (2008) cumulative talk and Alexander's (2008) discussion (i.e. cumulative discussion) but because of the limiting nature of the reflective elaboration by the teacher the verbal interaction did not quite extend into full exploratory dialogue (and therefore limited creativity-in-learning was reified).

There is also a commonality between excerpt 8.11 and this communicative exchange because no final correct 'answer' was communicated by the teacher. This is why the arrows illustrating this teacher-child interaction do not incrementally decrease or increase in size on table 8.3. The lack of any 'fixed' correct outcome is exemplified by the teacher when she finishes this interaction by exclaiming that even she cannot fathom an answer to this line of inquiry (line 245). Thus, whilst the children are free to articulate their subjective viewpoints (i.e. their autonomy was encouraged) the omission of what has, or is being learnt, through further rounds of teacher-child dialogue, leads to me suggesting that Bird's (2011) definition of the spirit of AfL was not being fully realised.

Following on from this second activity, in case C, was another which was referred to as Mrs Nerg (see figure 7.13a) and the following excerpt examined a minute's duration (minute 30) from the transcript of the whole class plenary.

8.4.3 Mrs Nerg (the seven life processes)

Mrs Nerg is an acronym to help remember what the seven important life processes common to plants and animals are. These are: movement, reproduction, sensitivity, nutrition, excretion, respiration and growth respectively. During this one-minute extract the teacher invites two children to articulate what they think the 's' stands for.

Teacher:	Okay what did we have for s. L.
Child:	Senses. Humans have senses, but like trees they sense ( ) Autumn, so they drop their leaves.
Teacher:	(.) They sense it's Autumn, but do they have other senses such as hearing. I mean, if I was to go over to that tree and say 'you know what you're looking a bit fat today' am I going to be hurting that trees feelings?
Children:	No, yes [laughter and chatting]
Teacher:	Erm. So L. is saying senses. J.
Child:	Er, start.
Teacher:	Start. Explain what you mean.
Child:	Well, all living things start from somewhere ( ) start somewhere.
Teacher:	Okay, so they have a start, like a life cycle. Okay, I quite like that one.

Case C: Excerpt 8.13

In excerpt 8.13 the initial idea, that the ‘s’ stands for senses, is reflected upon by the teacher and converted into a question (see lines 381-382), thus she is challenging the children to think more laterally (de Bono, 1992). Within this teacher-led probing something interesting occurs and is worth further contemplation, for the teacher speaks of a tree as if it possessed human characteristics, Dorion (2009:2262) referred to this as an ‘intermingling of [the] anthropomorphic and scientific’. Here the teacher is deliberately challenging the children’s thinking by reversing ideas or proffering alternate perspectives to be considered. Whilst I could claim that the teacher is simply expressing her creative risk-taking behaviour through innovative meanderings, Dorion referred to this as a ‘messiness’ of anthropomorphic analogies (*ibid*). Additionally, it was not clarified (i.e. there was no definitive response provided by the teacher) whether the learners were able to separate the trees humanisation from that of humans’ reality because the children’s perspectives were not interpersonally considered, i.e their little-c, as depicted in chapter 4 through my proposed model of creativity-in-learning (Figure 4.1) was not reified. Thus I am unable to discern the expressions of the children’s creative processes or their on-going developmental learning (i.e. the spirit of AfL). After this short ‘messy’ exchange the teacher asked another child for their thoughts on what the letter ‘s’ could be (lines 385-391). This restatement of the initial question, and gathering of an additional idea resonates with Alexander’s (2008) discussion where the ideas are being shared to solve a problem, however, no resolution was agreed or ‘given’, even though the participants were thinking creatively. This finding was akin to my interpretation of excerpt 8.12, thus it has been illustrated on table 8.3 in a similar fashion.

8.4.4 Positive, minus and interesting (PMI)

After the Mrs Nerg session was completed, there was a PMI challenge. This activity was also promoted by Holligan and Wilson (2015) to be a higher order thinking strategy (Collier *et al,* 2011), but it was originally devised by de Bono (1992) to encourage lateral thinking. In case C the teacher employed this activity to enable the children to consider what would be positive, minus or interesting if one of the seven life processes described through the Mrs Nerg acronym did not exist.

During this task, as illustrated through the events map (figure 7.13a), the children were first asked to individually reflect upon their own ideas, then following this to share their subjective thoughts with a peer or peers. Finally the whole class was seemingly brought back together for a class plenary. It is this third phase of the activity in which the excerpt below (8.14) transpired.

Child:	I, for interesting if we were, if we didn't grow and everyone was really small, would everything around us become really tiny for us to be able to [...teacher talks over child…].
Teacher:	Oh, what you saying is, so if all, say for example if all, if time stood still now, but we, in terms of growth, would, would there be some very tiny little things? Would we have to adapt society for everything being small?
Child:	Yeah, would this water bottle like, would they make water bottles smaller? For people to […teacher talks over child…]
Teacher:	[Laughs] Because we haven't grown?
Child:	Yeah.
Teacher:	I don't know. That is interesting.

Case C: Excerpt 8.14

The PMI activity was set up so that there was an expectation that there was no correct answer (McGregor, 2007:253) thus providing the incentive for the class to feel at ease enough to speculate (Davies, 2011:15). This level of exploration is evident in excerpt 8.14 when a young boy begins to express his creative wonderings about how the world would change if humans did not grow (lines 624-626). It is possible to argue here that the student is being reflectively critical but the teacher intervenes and then, according to Wragg and Brown (2001), elaborates on his initial contribution by exploring and echoing part of the idea whilst simultaneously converting it into a prompting/directive question (lines 628-630). This reflective questioning arguably motivated the learner to continue and elaborate upon his original notion (lines 631-632). Following this, further interest is conveyed by the teacher (*ibid*) when she intervenes again with another reflective question (line 633). Whilst these evaluative questions, asked by the teacher, are arguably designed to cognitively challenge the learner (Gillies *et al,* 2014), and this level of participation may have occurred on an intrapersonal level, further reasoning on the part of the child remained unarticulated because of the closed nature of the reciprocal question asked and so any creativity (as depicted in chapter 4) remained unvocalised. To rectify this the teacher could have extended her questioning to enable the child to think about 'what next' or 'what else'. However, the omission of these unspoken further cycles of (creative) criticality separated the child's on-going learning from the teacher, and as suggested previously in section 8.4.1 this leaves the extent of the child's ZPD concealed and the spirit of AfL left wanting.

I have illustrated this exchange on table 8.3 as two exploratory loops which lead back to the child's original idea. This return to the original stance is highlighted when the teacher expresses her own uncertainty about the child's thoughts (line 635). The movement back to the beginning I could argue exemplifies one of Sternberg's (2003) models of creativity, i.e. reinitiation: where there is a starting again due to not reaching a satisfactory conclusion (from the teacher's perspective). This tendency not to form a conclusion resonates throughout all the excerpts so far examined and I wondered if this trend would continue in subsequent discussion. The next excerpt contains part of the transcript from an activity which reportedly (Holligan and Wilson, 2015) also encourages higher order thinking. This is the ‘odd one out’ activity (Collier *et al,* 2011), again a strategy originally devised by de Bono (1992) to encourage lateral thinking, in which a child expresses her reasoning behind why she believes a teddy bear is distinct from two other objects.

8.4.5 The odd one out

During the ‘odd one out’ activity the children were shown three different pictures (one of a man, the other a teddy bear and the final image was of a chimpanzee). From these the pupils were invited to provide reasons why one may be different from the other. Below is the transcript from minute 52 which contains one child’s (somewhat anthropomorphic) subjective perception of why the teddy bear is not alive.

Child:	I think that the teddy bear is the odd one out because it doesn’t consume any food or drink and it doesn’t have any bones.
Teacher:	[Whispers] okay. [Normal voice] So do bones make things live?
Child:	No, it’s a skeleton.
Teacher:	Do all living things have skeletons?
Children:	No, no, no
	[…The teacher restates the question to another child *‘which one [out of the three] is the odd one out? without further consultation…]*
	Case C: Excerpt 8.15

The activity itself provides an open ethos so that the pupils feel free to articulate their speculative thoughts (Davies, 2011; McGregor, 2007). An example of their unique ideas can be found in lines 661-662 when a child makes the distinction that the teddy bear is different because it cannot digest nutrients and it does not contain any skeletal structure (i.e. bones), unlike the man or the chimpanzee. The teacher acknowledges part of the answer and then inflects her voice to convert this into a question (line 663). This is a technique she has adopted in all four of the previous excerpts. Whilst this, according to Wragg and Brown (2001) should invite the child to provide additional information the teacher’s question was classified as closed and so it funneled the child towards a ‘yes’ or ‘no’ response (Brown and Edmondson, 1984). The child responds initially with the latter answer but then goes on to propose that it is the complete skeleton and not the individual bones which indicate life (line 664). Here the child appeared to be critical of their teacher’s challenge, this arguably indicates some critico-creative practice and interpersonal (little-c) participation (Bird, 2011). However, the teacher inflects this into another closed question and diverts the child from further verbal communications by involving other children in the response (line 665). Thus I cannot claim this is an appropriate challenge to reify further personalised cycles of an iterative creative process (see chapter 4). Nevertheless there was an exchange of ideas and a final outcome was construed when everyone appeared to accept and agree that having bones was not necessarily a prerequisite for life. This initially seems contrary to previous excerpts where no overall final conclusions were formed. However, whilst this accommodates both Alexander's (2008) discussion and Mercer's (2008) cumulative talk to the extent that there appears to be the beginnings of interthinking (Littleton and Mercer 2013), where several individuals have contributed original (and developing) propositions through their verbal exchanges, the child whose ideas about the absence of a skeleton which were initially articulated was not given the opportunity to justify their response vocally (Gillies *et al,* 2014). Thus their justifications (and existing understandings) were not revealed through this exchange and the spirit of AfL was not fully enacted to elicit a comprehensive articulation of the child's vocalised thoughts.

8.4.6 Summarising the types of dialogue available in case C through five excerpts

Having now examined case C through five excerpts, the summarised illustrated results can be found in table 8.3 below.

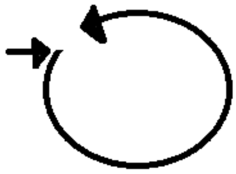
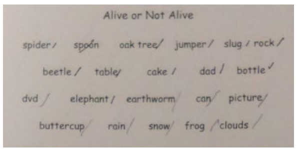
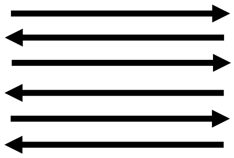
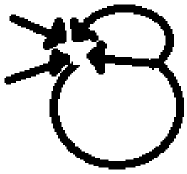
Excerpt number	Minutes in which excerpt takes place	**Associated picture** *(Ties each excerpt to case C's events maps, see figure 7.13a-b)*	Nature of talk observed in the excerpt	Diagrammatic representations of the direction and extent of verbal exchanges
8.11	7		Exploratory Dialogue - truncated (Alexander, 2008; Littleton and Mercer, 2013)	
8.12	17-18		Discussion (Alexander, 2008)	
8.13	30	Movement Reproduction Senses Nutrition Excretion Respiration Growth	Discussion (Alexander, 2008)	
8.14	49		Exploratory Dialogue - truncated (Alexander, 2008; Littleton and Mercer, 2013)	
8.15	52		Discussion (Alexander, 2008)	

Table 8. 3: Five excerpts from case C depicted as diagrammatic representations

The findings, as summarised on table 8.3, suggest that these open-ended activities provided ample opportunities for the children to express their own ideas. This has been illustrated in excerpts 8.12, 8.13 and 8.15 as an exchange of unidirectional ideas between teacher and child, i.e. through cumulative discussion (Mercer, 2008; Alexander 2008). However, similarly to case B (see section 8.3.6) there is no final outcome construed and this is why the arrows do not incrementally decrease or increase in size. This lack of a resolution was also evident in excerpts 8.11 and 8.14. However, unlike the other three excerpts, in case C, the verbal exchanges taking place in excerpts 8.11 and 8.14 have been depicted as a truncated from of exploratory dialogue. This occurred because the teacher was critically reflective through posing challenging questions (Gillies *et al,* 2014) which related back to the student's original creative ideas (hence its depiction as circular outlines), but the directive nature of the questioning style funneled the child's potential response towards a brief answer. Thus any intrapersonal justification of their original thoughts is not made explicit for further consideration. That is, their further creative meanderings or justifications for their propositions, post teacher questioning, was stunted and remained unheard in the interpersonal communication; therefore the creativity-in-learning that could be elicited through naturally embedded AfL was not fully realised.

Earlier in section 8.4 Presseisen (2001) outlined the behavioural characteristics of Bloom's higher order thinking skills through analysis, synthesis and evaluation; it is these features that I consider next, in order to clarify the nature and extent of thinking the learners were cognitively engaging in. Firstly, the ease with which the children proffered ideas and constructed their creative imaginings resonated with the behavioural facets associated with the category of synthesis. This was evident throughout all of the five excerpts. The cognitive process of analysis was illuminated in two of the five excerpts, for example when a pupil recognised how senses (the feeling of pain) and being alive (excerpt 8.12) were related or when another learner distinguished a difference between a teddy bear and two mammals (excerpt 8.15). This brings me to question whether the children in case C were more adept at synthesising than analysing, which is fascinating because synthesis is (arguably) rated more challenging than analysis in Bloom's taxonomy. If so does this provide some indication that Marzano (2001) was correct to question whether Bloom's cognitive categories should be considered on a hierarchical level. It was then fascinating to discover that there was evidence of Bloom's sixth category of evaluation apparently demonstrated in every excerpt. This indicates that the strategies employed by the teacher, as promoted by Holligan and Wilson (2015), can effectively incorporate all three of these higher order thinking skills, but I would argue that it was the teacher, not the children, who appraised, judged and was critical of the thoughts being articulated. Thus the child's evaluative practices were not illustrated and the spirit of Afl was constrained. However, I still go onto suggest that the children may have been cognitively challenged because not all participation is verbal (Bird, 2011), and they may have interacted with the teacher's creative and evaluative questioning on an intrapersonal level.

8.5 Reflecting upon the nature of teacher-child talk through cases A-C

It has been fascinating to examine all fifteen excerpts for it has provided an insight into how the reciprocal aspects of learning are (or could be) verbally illustrated within three science lessons. I shall briefly reflect upon my findings below.

As has been explained the verbal exchanges depicted in the excerpts were interpreted through a newly conceptualised framework. I had theorised that the application of this new classification system, to classroom transcripts, may be able to reify creativity-in-learning and illuminate naturally embedded formative assessment (i.e. the spirit of AfL), this I hoped would help me answer RQ4. Through my deliberations, whilst forming this analytical framework, see the literature review section 2.2-B.1.1.2, I was able to discern that a critico-creative pathway, essential when nurturing creativity-in-learning, required an exploratory dialogue. After analysing all 15 excerpts I interpreted this type of verbal exchange as being demonstrated through two of them (8.11 and 8.15). However, these were depicted as being truncated because the teacher's evaluative questioning, which reflected upon the children's original articulated thoughts, funneled the learners towards a vocalising a brief response instead of expressing any further reasoning. This brought to mind chapter 7, where I considered the concept of Vygotsky's ZPD requiring the interpersonal expression of both agentive learning, which resonates with Bird's (2011) description of the spirit of AfL, and appropriately timed challenges by the teacher. It is with this in mind that I have conjectured that Bird's (2011) description of the spirit of AfL, as described in section 8.1, needs to be reconsidered, and reviewed to elicit the pupil's agency-in-learning, that is, it requires rounds of communicative deliberation which includes the interjection of the teacher's risk-taking behaviour (their challenging of ideas) for the child's ZPD to be verbally articulated.

The notion of the ZPD being observed naturally led me to be curious enough to understand if this on-going developmental learning could be illuminated through cases B and C, despite the lack of exploratory dialogue, because the teachers had been interpreted (through my observational framework) as encouraging both autonomy and adopting risk-taking behaviours. By reviewing the excerpts above it became discernible that in case B I was inspecting the children's risk-taking behaviour, and not the teacher's. Additionally, I also noted that the directive guidance provided by the teacher limited the learners' independent agency. Thus I could not claim that the ZPD, as I had depicted it in chapter 7, was apparent. In contrast case C consisted of children proffering their own subjective ideas and a teacher who challenged them through reflective questioning. However any further intrapersonal justification of their original thoughts is not made explicit due to the closed nature of the teacher's subsequent questioning. That is, the shared cognitive spiral, of exploratory dialogue, which twists and bends back in on itself as ideas are critically and creatively conveyed is not revealed on an interpersonal level. Thus, any ongoing developmental learning (i.e. the spirit of AfL) is not verbally revealed.

Whilst reflecting upon the above I came across Coles (2015:237) who stated that

'…successful communication does not imply participants [teacher and pupils] share 'personal understanding', rather through joint activity we can come to share a common conceptual background'. Thus, Coles is suggesting that it is likely that more than one conceptual understanding could have existed, in a classroom of 30 pupils, even if exploratory dialogue had been reified. However, he goes on to advise that shared activities can enable participation, i.e. teacher and learner(s) could contribute to the task at hand through their individual developing knowing (Sfard, 1998). To further appreciate how the teachers, in cases A-C, involved the children through the activities I have summarised the descriptions of the actual lessons taught by each teacher in table 8.4 below (see 1st column per case). It is my intention to contrast these against the nature of talk evidenced, (2nd column per case), as construed through my examination of each of the excerpts. This should further help in understanding how creative enactments taking place endeavoured to develop creativity.

Case A: 'a history of light'		**Case B: 'dramatic science – Marianne North'**		**Case C: 'bright ideas time – life processes'**	
Description of lesson *(see section 7.2.1 for a richer description)*	**Nature of talk evidenced through five excerpts**	**Description of lesson** *(see section 7.2.2 for a richer description)*	**Nature of talk evidenced through five excerpts**	**Description of lesson** *(see section 7.2.3 for a richer description)*	**Nature of talk evidenced through five excerpts**
Handling and demonstrating unusual objects, whilst recounting tales of historical figures.	• Instructional (Alexander, 2008) • Recitation (Alexander, 2008) • Discussion (Alexander, 2008)	Employing a number of dramatic strategies, such as: monologue, hot-seating and freeze frame (McGregor and Precious, 2015).	• Recitation (Alexander, 2008) • Discussion (Alexander, 2008)	Open ended strategies to promote 'higher order thinking' skills, e.g. the big question, PMI and the odd-one-out (Holligan and Wilson, 2015)	• Discussion (Alexander, 2008) • Exploratory Dialogue – truncated (Alexander, 2008; Littleton and Mercer, 2013)

Table 8. 4: Descriptions of each science lesson (cases A-C) and the nature of talk as evidenced through the examined excerpts

By examining table 8.4 it becomes evident that the teacher in case A attempted to capture the interest of the children through an interactive session which was packed full of interesting, unusual objects which were demonstrated and described creatively by the teacher through the recounting of historical tales. The teacher in case B was summarised (in table 8.4) as employing activities which were designed to actively involve the pupils through their own ‘interactions with the physical and social world’ (Glăveanu, 2011:127). These reportedly providing opportunities for the children to articulate their own subjective creative ideas and critique other’s articulated thoughts (McGregor and Precious, 2015). Finally, in case C the teacher employed open-ended strategies which, according to Holligan and Wilson (2015) afforded the pupils ample openings to express and review their own and each other’s subjective understandings.

It is undeniable that all three teachers adopted a variety of creative strategies (these are represented further through their respective events maps, see figure 7.11-7.13 in the previous chapter) and these have created opportunities to enable their pupils to vocalise their thoughts and ideas via a number of different communicative means (such as through instructional talk, recitation, cumulative discussion and a truncated form of exploratory dialogue, see table 8.4 above), each of these interactions, Bird (2011) indicated, would have required and involved some form of intrapersonal (or unexpressed) participation (or knowing) on the part of the learner, however, none of these interactions have demonstrated the vocalisation of creativity-in-learning, as I have defined it in chapter 4 of the literature review.

Having considered the above I still find myself referring back to Coles (2015), yet again, when he suggested that understanding and appreciating everyone’s personalised understanding would be problematical when in the classroom (and I would agree with this statement). He went on to say that, ‘…all we can hope to do... is refine and work on how we make distinctions, through joint activities…[whilst] reflecting with others.’ (*ibid:*237). With this in mind perhaps, in order to attempt to foster creativity-in-learning, and illuminate the spirit of AfL, all we (as teachers and educators) can do is consider how the activities we choose to employ can be best articulated (or vocalised) across participants (i.e. through both the teacher and their students).

Chapter 9

Teacher views of developing and fostering creativity in the science classroom

9.1 Aims of interviewing three teachers to discern their perspectives on nurturing creativity-in-science

In this chapter I will examine three teachers' responses to 11 questions (see appendix 5.K). These questions were designed to capture their personalised perceptions of how to augment and assess creativity through their teaching practices. The teachers' responses from interview questions 1-8 will be examined to elucidate the ways in which they believe they are supporting creativity in their primary science classroom and these will be contrasted with the observations of their actual lessons. This information is used to respond to research question (RQ) 1. Whilst the analysis of questions 9-11 will inform how teachers describe the different strategies used to assess pupils' progress in science and to capture how these could be (or are being) employed to evaluate the child's creative efforts. These latter set of responses provide evidence for responding to RQ3.

9.2 Gathering and considering teachers' views of creativity within primary science lessons

Five teachers were invited to take part in this stage of this study. All interviews took place between July 2015 and January 2016. Three of these interviewees were the same teachers observed and videoed previously (cases A-C) in chapter 7 and two were involved with the Thinking, Doing and Talking Science Project (TDTSP), as described in the methodology chapter, section 5.6.1.4. However, having reflexively considered all five (Alvesson and Skoldberg, 2009) I decided to focus my attention on cases A-C. This seemed a prudent measure for triangulation purposes, because it was this set of three observations that had been originally chosen to contrast and illuminate the distinctive features of expositional teaching, 'teaching creatively' (TC) and 'teaching for creativity' (T4C) (see chapter 7).

In this chapter, I not only plan to triangulate my interview data with the observational findings I also intend to cross-reference a number of the interview responses with the results from the survey data (see chapter 6). This will be achieved by applying two devised analytical frameworks, used in chapter 6, to a number of the interview responses. To this end the answers collected from questions 2 and 8 (which triangulate with survey questions 8 and 9, see appendix 5.K) will be examined using a classification system originally described in the methodology chapter (section 5.6.1.6.2.2). This framework was adapted from Oliver's (2006) ten ways to make science teaching creative. Following this, the responses from questions 9, 10 and 11 (which triangulated with survey questions 15, 16 and 17, see appendix 5.K) will be analysed through a second framework which was conceptualised with Wiliam's (2011) five key strategies of formative assessment in mind. This second framework is described in the methodology chapter, section 5.6.1.6.3.2. The deductive examination of the interview data will be conducted throughout this chapter as and when appropriate (see sections 9.4 and 9.10 respectively).

Prior to the above analytical approach, I inspected the responses from all of the 11 interview questions through an inductive grounded approach, as described in the methodology chapter (section 5.6.3.5.1). The results of this examination can be found in the following sections (9.3, 9.6, 9.7, 9.8, 9.9 and 9.10). All but three of these 11 interview questions have been triangulated with those asked in the survey (see appendix 5.K).

This two pronged inductive/deductive approach was chosen because of advice taken from Patton (2015) and Glasser and Strauss (2006) who stated that using a grounded approach before examining the data through a devised framework is expedient, because some things can be overlooked or discounted by applying logically deduced theories.

9.3 Inductively elucidating how teachers describe and promote creativity in their science classroom

The summarised data in appendix 5.K indicates that the interview questions 1, 2, 3 and 8 were designed to illuminate how the teachers being interviewed referred to and promoted creativity in their science classroom. That is, the teachers' answers to these questions were intended to respond to RQ1. The questions were:

1) How would you, as a teacher, describe creativity within i) teaching and ii) learning?
2) Can you provide some examples, from your experience, of i) your most creative teaching and ii) the children's at their most creative during science?
3) What are the benefits for the children, in your experience, of i) creative teaching and ii) creative learning?
8) How do you ignite creativity in your science lessons?

It is intended that this initial inductive examination of the responses from these four questions above will elucidate how far observed practice (see chapter 7) reflected reported teacher values. The outcome of this comparison will be summarised in detail at the end of this section (see 9.3.4). I reiterate the importance of this contrast because, as previously stated, research by Johnston (see methodology chapter, section 5.5) had indicated that there may be a mis-match between the teachers' espoused views (such as those articulated through a survey and/or interviews) and what was actually enacted during science lessons.

The individual teacher's responses, to these four questions, have been inductively examined as a single group. This was because all four questions were designed to respond to RQ1. However, I also wanted to consider whether the teachers reflected upon the development of creativity as being either teacher-led and/or child-initiated in order to consider creativity in both teaching *and* learning. To appreciate this further I examined the teachers' responses and then sub-coded them into bilateral categories, which were, 'teacher-initiated creativity' (TIC) or 'child-initiated creativity' (CIC). Thus the teachers' reports of creativity in their classrooms were, whilst being inductively analysed, also simultaneously categorised as being either TIC and/or CIC. As previously explained, if the responses lacked clarity regarding who was leading them then they were coded as a 'creative classroom activity' (CCA); to be coded as a CCA a creative strategy may have been described without the teacher indicating who was leading it (teacher or child). This approach is akin to that which was originally employed when analysing survey data (see methodology chapter, section 5.6.1.6.2.2). The results of this examination are displayed in tables 9.1-9.3 below, from case A to C respectively.

9.3.1 Case A: A teacher's perception of ways to augment creativity in a science lesson

Below (table 9.1) are the themes that emerged from the grounded examination of the teacher's responses (from case A) to questions 1, 2, 3 and 8. All have been sub-categorised into TIC, CIC or CCA classifications. These themes will be examined below, in this section, through apt examples of the teacher's articulated responses.

CCA	TIC	CIC
	• Encouraging autonomy • Open ended investigations • Answering all the children's questions • Taking-risks	• Being autonomous • Open-ended discoveries • Generating their own questions

Table 9. 1: A summary characterising the nature of creativity, as evidenced through analysis of the transcript, from case A's interview

The summarised findings listed in table 9.1 indicate that the teacher developed both TIC and CIC, evidenced through her verbal articulations (i.e. none of the verbally expressed descriptions of creativity were classified as a CCA). At one point during the interview she even tries to indirectly highlight this distinction through her own personalised reasons for being in the teaching profession.

> 'There is no point in my teaching if the child isn't learning […] I think a lot of the teaching of the past and that is teaching that I grew up with was the teacher demonstrating and saying it and read this chapter and now you know all about this and it's not the same as learning.'

This difference between teaching and learning, is exemplified further by the teacher through her descriptions of her story-telling approach (originally described in chapter 7, section 7.2.1). She reports that this telling of historical tales can enable the children to have autonomous thoughts and ideas, independently of the teacher.

> '…the child is able to imagine a different life, a life into which they fit and they then realise that people in the past solve the same problems that they are solving today. How do I get food? How do I keep myself warm? How do I get pure water? So that […] they become terribly interested in it and finding out more how those people did it.'

The above quotation suggests that the teacher believes her storytelling approach during science lessons, enables the children to generate these lines of enquiry autonomously, and that this is achieved through being informed by an historical story to help them see the science from another person's (a scientist's) perspective (McGregor and Precious, 2015; Oliver, 2006). In fact, in one specific example the teacher encourages the children to think like Archimedes (a 3rd century Greek mathematician, scientist and inventor); illustrated by, *'You [the teacher] give them a heavy piece of stone to move [……] and see who could work out eventually that a pulley would help…so you set up the experiment which they will get something out of it'.*

The above is an example of a creative episode where a teacher sets up the open-ended investigation (TIC) so that she can offer independent control of the investigation to the children (CIC). This description is an activity which represents the sequential movement between the two juxtaposed elements of classroom creativity, as described by Jeffrey and Craft (2004). That is, the teacher describes her approach transitioning from TC were the emphasis is on the way she teaches imaginatively, to T4C where her practice invites children to express their own creative ideas (Davies, 2011:114). She goes on to say that this way of promoting creativity motivates the children *'…to take part, to touch, to sense, to become more involved in what either subject it is…. it's very stimulating. It gets their brain working and gets them asking questions'*. In this example the teacher has maintained the importance of allowing the children to generate their own ideas/questions. She then even goes onto emphasise the significance of her, as a teacher, challenging any alternative considerations, i.e. she believes she takes risks if (and when) required,

> 'I think one has to try and answer all questions as if they are serious and sometimes if it is a stupid question and you answer it seriously the child realises that they have strayed and then they'll come back, they'll come back with a more sensible question.'

Here the teacher is identifying the consequences of a flexible teaching approach, and the necessity of responding appropriately to alternative ideas and suggestions (Cremin *et al,* 2013), although what she means by '*a sensible question*' is not clear. Nevertheless, she is acknowledging how the teacher is the crucial connection between the expressed thoughts and ideas of the child and the knowledge being conveyed. This is especially important if an inappropriate answer to a poorly phrased question could be construed as an accurate conclusion by the child if it is not given further critical scrutiny (Driver *et al,* 1994).

9.3.2 Case B: A self-reported insights into how to support creativity during a science lesson

In contrast to a story-telling approach the teacher, in case B, incorporated a number of McGregor and Precious' (2015) dramatic strategies (see section 7.2.2); Glăveanu (2011) reported that these kinds of activities could involve both physical and social interactions on the part of the child. It was interesting that, after examining the responses from the teacher in case B, the themes which emerged (see table 9.2) were somewhat akin to the previous results from case A (see table 9.1). Each of these themes will be illustrated through the verbal articulations of the teacher below.

CCA	TIC	CIC
	• Encouraging autonomy • Open ended strategies • Asking open-ended questions	• Being autonomous • Open-ended discoveries

Table 9. 2: A summary characterising the nature of creativity, as evidenced through analysis of the transcript, from case B's interview

The results, as summarised in tables 9.1 and 9.2, indicate that both teachers, in cases A and B have referred to encouraging autonomy, and the necessity of the children thinking or acting independently of the teacher, through the employment of open-ended strategies, where the children are agentive in their learning. It therefore appears that both teachers can differentiate between TIC and CIC. This is supported by the fact that there are no descriptions of a generalised CCA on either table of results (as indicated by the black columns in tables 9.1 and 9.2). I believe this indicates that they both discern the difference between TC and T4C. This is highlighted by the teacher in case B when she points out *'…you can help children develop it [creativity] by giving sort of open questions and giving them things for them to explore for themselves [thus reifying TC] so they can come up with their own ways of doing things [enabling expressions of T4C]'.* Whilst she does not explain how this directly relates to her observed science lesson an activity does come to mind. During the freeze frame activity (originally described in section 7.7.2 of the observational chapter) the teacher invited three groups of children to physically represent the different layers of the rainforest canopy with their bodies. Those pupils' who went on to observe their peers physical movements were invited to review and critically consider their classmates' enactments through questioning. In section 8.3.3 of chapter 8 I went on to note how the teacher, during this activity, helped the children *'develop their open questions'* when she directed the on-lookers to consider asking their peers *'why they were moving as they were?'.* This is a prime example of Davies's (2011) depictions of both TC and T4C, for the teacher is communicating (even directing the) science (and questions) creatively but the subsequent focus is on the children and their physical and verbal expressions (Glăveanu, 2011).

This exemplification of both TC and T4C is acknowledged further during the interview when the teacher described an investigation into the properties of magnets,

> 'If you put magnets out on a table…you can't say 'no, don't touch them'…They do try things out [….] if you don't allow that in your lessons, you don't fill the time in for children to just say 'oh, come and look at this', you want them to come up with interesting experiments'.

Thus this teacher is indirectly highlighting the two apposite aspects of creative teaching through adopting an imaginative way to teach through drama (TC) and inviting the children to express their own thoughts and ideas (T4C).

Whilst the teacher acknowledges the relevance of fostering autonomy through a creative approach unlike case A, no mention about how the teacher believed she took risks (i.e. how she challenges the children's alternative conventions). This is despite the teacher identifying the importance of the children working scientifically. She stated that by being independent, *'they understand how to work scientifically rather than being told how. They have to work out how to do it'*. One of the many facets of working scientifically is cited as being critical of ideas (McGregor and Precious, 2015) and I had conjectured, in chapter 7, that the teacher adopting a risk-taking behaviour can help learners to learn to evaluate their own subjective thinking (and outcomes). This was indirectly mentioned by the teacher in case A (see section 9.3.1) and in the latter part of the following section (9.3.3) it is referred to by the teacher in case C.

9.3.3 Case C: Self-reported insights into how to support creativity during a science lesson

After examining the teacher's interview responses, from case C, the themes which emerged continued to resonate with those of case's A and B (see table 9.3).

CCA	TIC	CIC
	• Encouraging autonomy • Open ended strategies • Taking-risks	• Being autonomous • Open-ended discoveries

Table 9. 3: A summary characterising the nature of creativity, as evidenced through analysis of the transcript, from case C's interview

As stated above, when table 9.3 (i.e. case C's summarised results from the data analysis) is compared to tables 9.1 (case A) and 9.2 (case B) similar themes have emerged. For example, all three teachers' expressed how they employed or introduced imaginative ways to communicate about science (TIC) which subsequently also invited the children to work or think creatively and independently (CIC). Additionally, both the teacher in case A and this practitioner, from case C, highlighted risk-taking as a necessary characteristic of their teaching to develop creativity. The teacher, in case C, also recognised the difference between TIC and T4C (similarly to the teachers' in cases B and C). Examples of this teacher's ability to verbally articulate how apposite these teaching practices (TC and T4C) are can be found below.

This teacher spoke at considerable length about the five characteristics summarised in table 9.3, and what they meant personally to her, for example,

> '…creativity within teaching is, in my opinion […], providing opportunities for all children…[where you] don't already know the answer but you are giving the children the opportunity to apply their skills and knowledge in […], a more exciting context perhaps, and in terms of learning I think it's giving children the opportunity for discovery […] that can be discovering the unexpected'

In the above example the teacher is articulating her perspective of what characterises an imaginative teacher-initiated open-ended strategy (TIC). She then speculates how this can result in an opportunity for the children to undertake their own discovery learning (CIC) to formulate something unusual (i.e. unexpected). This was evidenced in the observation of her lesson (see chapter 7, section 7.7.3) in which she drew upon six different techniques, not commonly used in teaching primary science, which she believed enabled the learners to actively engage in 'higher order thinking' (Holligan and Wilson, 2015). Most of these have been recognised (Collier *et al,* 2014) or designed to support divergent thinking (de Bono, 1992).

She goes on to summarise the two apposite approaches of creative teaching when she describes a cup telephone investigation.

> '…we did cup telephones. So children had a variety of equipment but the only thing I said to them was you need to explore cup telephones. So they had different strings, wools, fine thread….. They had different kinds of cup, they

> had the opportunity to be inside or outside or have really long thread. They had the opportunity to be one inside, one outside. So it's setting something up where they can plan, where they can use the resources'.

This is, in my opinion, the perfect example of a teacher resourcing and planning an original investigation (TC) but then empowering the children to develop their own experimental designs (T4C).

This teacher, however, recognises that independence in scientific explorations may be problematical, especially as she said, *'when you've got twenty odd children all with a different view of creativity…you've got to be prepared to run with it'.* It is here that I believe the teacher appears to be describing or modeling a tolerance of ambiguity, which corresponds to Cremin *et al's,* (2013) definition of encouraging autonomous learning. I can think of a couple of examples where this kind of flexibility was illustrated by the teacher when I observed her teaching, both of which occur during the 'is it alive or not alive' activity (a task whereby the teacher invites the pupils' to place 21 distinct items into two separate columns entitled 'alive' and 'not alive').

On the first occasion when this articulation of accepted uncertainty was demonstrated, a child expressed their subjective understanding that rain could be alive and they stated that this was *'because a substance from another thing [a cloud] is alive'*. For additional clarification the teacher asked for '*another example'* and the child suggested that somebody could throw up and '*that [substance] would be alive'*. The teacher demonstrated her acceptance of this rather gruesome suggestion by readily acknowledging it as a point for further consideration. This she achieved by elaborating upon it and reflecting it back as a question, she stated, *'It depends what they threw up. So what you're saying is was, oh, this is a horrible question but, was the thing inside you alive before it came out of you?'.* A second less grisly example of this type of exchange, from the same activity, is provided and described in greater depth in the previous chapter, see section 8.4.2.

However, if this level of independence is allowed to flourish in a classroom of 20 or more students, Driver *et al* (1994) warned that not all the participants may necessary have understood the science that was intended to be learnt in that lesson. This, according to Cremin *et al* (2013) is where risk-taking could be advantageous because, as already stated in section 9.3.1, by challenging the pupils' viewpoints the teacher becomes the link between the expressed (and unarticulated) thoughts of a child and the scientific knowledge being conveyed. The teacher in case C directly refers to this in her interview *as 'challenging* *predictions [during investigations]'* and having the *'opportunity to dispel preconceived ideas about their understanding'.* Although this is contrary to the example given above, where the teacher did not challenge the idea of a vomited substance being alive. With this teacher describing both autonomy-in-learning and acknowledging a risk-taking behaviour as being integral when augmenting creativity, it is interesting to contrast this with how she, in actuality, supported the development of creativity. By referring back to sections 8.4.1-8.4.5 when I examined the verbal interactions between the teacher and the children, it is possible to discern that the challenging of ideas by this teacher was evident in all five of the excerpts, illustrated by her probing questions to re-direct the children's thinking to see things afresh.

9.3.4 Reflecting upon the teachers' self-reported views of creativity and contrasting them with their practice in creative science lessons

The inductive analytical approach has elucidated ways in which the teachers perceived their practice promoted creativity. One way was noted to be through the teacher encouraging autonomy which subsequently enabled the children to be independent through open-ended investigations. This was reportedly achieved whilst challenging alternative ideas and suggestions. However, I have wondered how these compared to all three teachers' observed actions in their science lessons because, as stated in section 9.3, a previous study discovered there was little relationship between the teachers' espoused views (such as those articulated during an interview) and what actually occurred during science lessons.

My observational graphical representations of case A's science lesson (figures 7.2a-c and 7.5a-c), which represented when the teacher encouraged autonomy and took risks respectively, indicated that this teacher tended to minimise opportunities for the children to develop their agency-in-learning and not challenge any pupil ideas. By referring back to chapter 8 I could infer that this may have occurred because her interactions with the learners were mainly interpreted as recitation (Alexander 2008) which tends to be directive (teacher to child) in its nature (see table 8.1). This approach is contrary to her claims made during the interview (see table 9.1).

In contrast to case A, the teachers from cases B and C, according to the analysis in chapter 8, exchanged ideas between teacher and child, in the main, through cumulative discussion (see tables 8.2 and 8.3). Whilst all three teachers employed opportunities to elicit and appreciate different perspectives (Wells and Arauz, 2006), the teachers in cases B and C were not seeking specific scientific answers and this provided them with more openings to encourage learner independence. It is this autonomy that is illustrated on both their respective graphical representations (figures 7.3a-c and figures 7.4a-c respectively). This is consistent with the inductive themes that emerged through my analysis of the interview data, which suggested that both teachers encouraged independence so that the children could be autonomous (see tables 9.2-9.3). During the interview, the teacher from case C went on to claim that she also challenged preconceived ideas (i.e. took risks) in her science lesson and this corresponds with my observational findings (see figures 7.5a-c). It is interesting at this point to note that the teacher from case B, who was also interpreted during her observation as taking risks (figures 7.4a-c), did not recognise risk-taking as challenging children's idea (see table 9.2). This is contrary to Johnston's (2007) findings, because not all of the teachers' articulated thoughts which related to their teaching practices conflicted with what was interpretively observed in chapter 7. That is, there was no mis-match between these teachers' espoused views (i.e. cases B and C) and the events taking place in during their observed science lessons.

9.4 Considering Oliver's (2006) ten ways of making science teaching creative when examining three teachers' reflections of their practices

As I stated earlier in this chapter I also intended to cross-reference the interview responses with the results from the survey data. This process begins by examining the data collected from questions 2 and 8 through a classification system adapted from Oliver's (2006) ten ways to make science teaching creative (as originally described in the methodology chapter, section 5.6.1.6.2.2). Question 2 of the interview (i.e. *Can you provide some examples, from your experience, of i) your most creative teaching and ii) the children's at their most creative during science*?) resonates with survey questions 8 and 9, whilst the eighth interview question (*How do you ignite creativity in your science lessons?*) triangulates with the eleventh question on the survey (see appendix 5.K).

My conceptualised theoretical classification system examines the data bilaterally. The first step in this two-pronged approach includes distinguishing the number of times each of Oliver's ten categories are illustrated through the teachers' verbal recounts of their practice (see appendix 6.A) and this is followed by considering which aspects of creative teaching approach are described by the teachers. This involved a similar method to that of the second stage described in section 9.3, that is, the reflective reports of creativity in the classroom were considered to determine whether the activities were teacher (TIC) or child initiated (CIC). When it was not possible to categorise activities as teacher or child initiated they were identified as a CCA. This enabled me to examine where the agentive origins of the creativity in the science lesson lay (with the teacher or the learner). The results from each question were processed in the same manner as the survey data and thus the findings from this deductive approach can be compared and contrasted (triangulated) to those in chapter 6, where appropriate.

9.4.1 Deductively examining self-reports of the teacher and their pupils at their most creative during science lessons

Table 9.4 below summarises the bilateral analytical process undertaken after examining the reflections of the teachers reporting when learning or teaching is most creative.

Oliver's ten ways to make science creative	Number of times category demonstrated as a CCA	Number of times category demonstrated as a TIC	Number of times category demonstrated as a CIC	**Total number of times each category is demonstrated**
Turning predictable outcomes into something better	0	0	3	3
Making the ordinary fascinating	0	1	2	3
Sharing a sense of wonder	0	0	0	0
Seeing differently	0	1	3	4
Maximising opportune moments	0	0	1	1
Humanising science	0	0	1	1
Valuing questions	0	0	2	2
Modelling explanations	0	1	2	3
Encouraging autonomy	0	0	5	5
Allowing for flexible beginnings	0	0	0	0
Accumulative Total (and %)	0 (0%)	3 (14%)	19 (86%)	22

Table 9. 4: An analysis (applying Oliver's 2006 perspectives) of teachers' reflections regarding their views of exemplary creativity in their classrooms

The analysis of the teachers' responses to question 2, summarised in table 9.4, indicates that 86% of the reported science activities described by the teachers were child-initiated, whilst 14% originated through the teacher. It was fascinating that none of the responses were classified as being a CCA, that is, I was able to discern who was agentive from the teachers' reflective descriptions. Whilst this corresponds with section 9.3 above, it is contrary to my findings from chapter 6, where the majority of the written accounts were classified as being a CCA. I had previously suggested, in chapter 6 (section 6.2.1.2.4), that this lack of clarity when teachers are thinking about creativity indicates a focus on the innovation or novelty of activities rather than clearly delineating between TC and T4C. These interviews suggest that questionnaires or surveys indicate the contrary. That is, there appears to be limitations in collecting data specifically about *teaching creatively* and *pupils being creative in their learning* through the written format.

The four most prevalent of Oliver's ten ways to make science creative (as summarised in the survey chapter, section 6.2.1.2.5) were: *making the ordinary fascinating, modelling explanations [creatively/imaginatively], seeing differently and encouraging autonomy.* The latter two of these four are the most frequently cited in table 9.4 (n=4 and n=5 respectively). The former two are also associated with all three interviewees responses (both cited as n=3). During the interviews, I was also able to discern that these three teachers' augmented creativity by not following prescribed routes, that is, they also *turned the predictable into something better* (n=3). Interestingly, this was not a frequently referenced category in chapter 6. Is this because it is easier to probe further in an interview to elicit more precise information than through a questionnaire where the respondee may be more pressed for time? This application of Oliver's category is, perhaps, not that unexpected when the interviewees appeared to be advocating numerous autonomous (discovery) investigations, such as those which allow the children to follow their own interests or inquiries. One teacher commented that she used this approach, *'…because quite often they will have much better ideas than we do and also if they've come up with the ideas then they are much more engaged',* which is why she tended to ask them *'what do you want to find out?'*

The example below describes an activity, described by the teacher in case C, which I believe *turned the predictable into something better*. It was interpreted as being teacher-initiated (TIC), but it contained an exploratory opportunity for the children to work independently of the teacher and/or any prescribed plan (i.e. it was also CIC).

> 'I gave the children…a box of material, a box of mirrors, there was tape and bits and pieces like that […]. So some of the children invented some things like periscopes devices for seeing around corners. Some of the children [were] inventive like [in] a maze, to direct a torch beam through the maze. Some of the children wanted to use different materials to make black out blinds. So they kind of took it whichever way they wanted to and one of the really good things about that was at the end, or towards the end of the session each group presented their ideas. So they had to present why they had chosen to do a particular thing, how they had done it and what they had found out. So the idea was that in the next session the children could try another thing. It might be that they were quite inspired by the maze for the torch beam

and they had realised what had worked well or how it could work better or what hadn't worked so well and what could we do differently'.

Here the teacher had supplied her pupils with numerous resources from which the children were encouraged, but not instructed to, create/design their own outcome through exploring and playing with supplied items (i.e. their *autonomy or agency was encouraged*). The items were everyday objects (e.g. mirrors, boxes and tape etc.) and the children reportedly generated a diverse array of investigatory phenomenon (e.g. periscopes, devices for seeing around corners, mirror mazes and blackout blinds), that is, they *made the ordinary [into a range of] fascinating* products. This may have provided the ideal opportunity to develop a relationship between the scientific and what was familiar (through *modelling explanations*) but whether this, in actuality, transpired I cannot be certain. Following this activity the children were provided with further opportunities to display and examine each other's work which would have allowed them to see alternate ways of doing similar things and indeed, afford the possibility of reflecting upon own efforts from fresh perspectives, (akin to *seeing things differently*).

The interviewees relayed how they thought themselves and/or their pupils' to be at their most creative. These were identified as activities that *made the ordinary fascinating, modelled explanations, saw things differently and encouraged autonomy,* (findings which were consistent with the surveys). In addition, however, they also reported they employed these kinds of approaches in a flexible way, without having a predefined structure to their science lesson (i.e. they often *turned the predictable into something better*).

9.4.2 Deductively illuminating the elements of the teachers' self-reported practice which have sparked the children's interest in science

The eighth interview question invited the teachers to consider how they kindled or ignited the children's interest in science. After considering the teachers' responses, with Ann Oliver's ten categories in mind, I summarised the data in the same manner as section 9.4.1 and generated table 9.5 below.

Oliver's ten ways to make science creative	Number of times category demonstrated as a CCA	Number of times category demonstrated as a TIC	Number of times category demonstrated as a CIC	**Total number of times each category is demonstrated**
Turning predictable outcomes into something better	0	0	3	3
Making the ordinary fascinating	0	1	2	3
Sharing a sense of wonder	0	0	0	0
Seeing differently	0	1	0	1
Maximising opportune moments	0	0	0	0
Humanising science	0	0	1	1
Valuing questions	0	0	0	0
Modelling explanations	0	2	1	3
Encouraging autonomy	0	0	3	3
Allowing for flexible beginnings	0	0	0	0
Accumulative Total (and %)	0 (0%)	4 (29%)	10 (71%)	14

Table 9. 5: Teachers' reflective descriptions of the ways (adapted from Oliver 2006) they believe they have ignited children's interest in science.

The data in table 9.5 illustrates a similar trend to that in table 9.4, that is, the majority of the verbal reports of promoting creativity (71%) were construed as being initiated by the child (CIC). The remaining 29% focused on how the teachers tried to stimulate interest (TIC) and innovate the children's thinking and learning. It is fascinating that again none of the teachers' responses were classified as being a CCA; this being somewhat different to the findings from the survey data (see chapter 6).

The four most notable ways to ignite interest in science, reported by the teachers (cited in table 9.5) were *encouraging autonomy, making the ordinary fascinating, modelling explanations* and *turning the predictable into something better*. It is noted worthy that these same four of Oliver's categories were sighted by all the teachers in their responses about when they and the children were at their most creative (see section 9.4.1).

Examples of activities that the teachers stated can spark interest in science included setting up an historical experiment (something akin to a 3rd century Archimedes lever and pulley system) and letting the children work out how to move a heavy everyday object (this has already been described in section 9.3.1); exploring the properties of magnets (see section 9.3.2) through a child-led (teacher independent) investigation or providing pupils with various materials to create cup telephones to explore unusual modes of communication in different environments around the school grounds (described in full in section 9.3.3). These kinds of investigations are teacher-initiated but designed to allow the children to be agentive and lead their individual lines of enquiry. This encouragement of self-sufficiency (T4C), followed by the children actually being independent (CIC), also corresponds with the survey's most frequently cited way to ignite interest in science, that is, *encouraging autonomy* (see section 6.2.1.2.4).

References to supporting independent learning appeared to resonate throughout all the interviewees' verbal accounts of T4C and CIC. Additionally, each of the investigations identified above incorporated three more of Ann Oliver's ways to make science teaching creative. They reportedly involved: the pupils having to work out the experimental processes for themselves (*autonomy was encouraged*); an open-ended structure to the activities which meant that the teachers were prepared to deviate from their lesson plan (a fitting example of my interpretation of *turning the predictable into something better*) and finally they provided opportunities to develop a relationship between the scientific and the child's everyday, which was reinforced through the use of the resourced (familiar) materials employed during the activities, and this is akin to two other of Oliver's descriptions: *making the ordinary fascinating* and *modelling explanations*).

9.5 Summarising my examination of how teachers describe nurturing creativity in their science classroom

The deductive examination of the teachers' descriptions of creativity (see section 9.4) has revealed how the teacher appeared to employ naturally occurring everyday phenomena, to build a relationship with the scientific, which, in turn, provided the children with opportunities to discern the world from another vantage point. This was perceived as being achieved by the teachers facilitating open-ended investigations but subsequently controlled by the learners. This summary of the results from the interview data, as deduced through my theoretical framework resonates with the findings from the survey data (see chapter 6). My inductive analytical approach (section 9.3) also illuminated similar findings, for the teachers perceived themselves as encouraging autonomy which subsequently enabled the children to carry out independent inquiries although the teachers provide pre-determined resources. There was, however, an additional finding elucidated through the grounded approach, that is creativity in science was also supported by challenging the children's alternative ideas and suggestions. This was most clearly demonstrated by the teacher in case C through reflective questioning (see the previous chapter, section 8.4). I found this fascinating because questioning the learners (a frequent component of classroom interaction) was one of the least commonly coded categories identified by teachers in chapter 6, and it was also not *directly* recognised by the teachers being interviewed. I am not claiming that through the teachers participating in the survey, or interview, do not use questioning as a tool to encourage originality (in thinking), just that they did not identify it as a key strategy. It is evident in the observations that all three teachers frequently adopted this practice (see figures 7.1a-c) to engage children in thinking or doing something differently or uniquely (see section 7.3).

Having elicited how teachers (self-reported in the survey and interview questions) the ways they promoted creativity (thereby answering RQ1), I endeavoured to triangulate the survey data with the interview responses. To this end, questions 12 and 13 triangulate with question 4 and 5 and further explore challenges faced by both teacher and child when encouraging and supporting creativity in the science classroom. Questions 4 and 5 are: '*What are the challenges for you as a teacher, when developing creativity in the confines of the science lesson?' and 'What are the challenges for the children to be creative when in a science lesson?'*.

9.6 The teachers' self-reports of the challenges they face when endeavouring to promote creativity in the science classroom

Question 4 was designed to be triangulated with question 12 from the survey. The responses from each of the three teachers to this question have been examined inductively and the themes that emerged have been displayed in table 9.6 below.

Case A	Case B	Case C
• pedagogical content knowledge (PCK) • Generating the creative activity	• pedagogical content knowledge (PCK) • Generating the creative activity	• Encouraging autonomy • Assessment • Resources • Time

Table 9. 6: A table to demonstrate the challenges faced by three teachers' when they develop creativity in science

It is fascinating that the teachers from cases A and B both described elements of Shulman's (1986) PCK in their responses to question 4. Shulman himself referred to this concept as '…[communicating] the subject [matter, in this case science,] to make it comprehensible to others' (*ibid*:9) through the generation of creative 'analogies, illustrations, examples, [and] explanations' (*ibid*). Alexander (2010:307) puts it more succinctly when he stated that it is about 'what the teacher needs to know about each aspect of the curriculum in order to restructure it as successful learning encounters and experiences'. I found it intriguing that the teacher in case B appeared to suggest that she did not consider herself as lacking this ability and even provided various ways the concept of friction could be taught, such as

> '…instead of using cars and ramps, for example, which is used frequently for changes of friction (4 secs) you could use anything else, [teacher laughs] like these little toys that you have and get children to may be just run and slide in the hall, which they love doing. Wearing different sort of things on their knees and seeing the difference with that. So you're just coming up with a more engaging and different way of testing the same sort of thing really'.

However, she went onto explain why other practitioners may find this problematic, *'I think for the people who don't have the pool of knowledge…it's not so easy thinking up a creative way of teaching particular concepts'.* The teacher's response in case A appeared to correspond with case B, when she talked about the difficulties of directly linking the scientific content (or facts) with an appropriate creative way to communicate them (in her case through a historical narrative).

> 'To, to know what you are trying to put over and then find the story that actually leads to that because if you give the wrong the story I think you'd muddle the message, so you've got to be very clear as the story teller what fact you are trying to get over'

Having elucidated both teachers' thoughts on the complications of associating scientific content with an appropriate activity, it was the teacher in case C who was concerned about how to monitor whether the science being taught (or communicated creatively) had, in reality, been understood by the child. She stated, *'…how do you know that the activity has moved their science understanding forward. How do you monitor it? How do you assess it? …I haven't got the answer to that [laughs]'*.

Upon examining the third teacher's responses in further depth it was interesting to uncover that she believed that the difficulty was not in how you, the teacher, articulated or illustrated the science but the ability of the teacher to allow the children to discover the science for themselves (i.e. be autonomous);

> 'You kind of know what you're hoping the children will achieve but sometimes they won't go actually the route… if you are setting up being creative you can't suddenly turn around and go 'oh, don't do it that way', You've got to allow them… the opportunity for it not to work (.) in order to reflect on that and have another go'.

Here the teacher is referring to the adult's capacity to support *and* encourage autonomy so that the children are afforded the opportunity to work independently. Further to this she went on to highlight how resourcing these types of open-ended activities can also be an issue, *'… if the children do come up with a great idea it's […..] having the resources to do it, so it's making sure you've got the stuff available'.* She followed this up by mentioning how time is required to allow the children to discover, *'I think it's also allowing [thinking] time, in terms of challenge, is allowing time for it to work, or for it not to work, either which way'.*

It is interesting that the survey results (section 6.2.1.3) highlighted resources and time as being the main reasons why teachers thought it was difficult to be creative during a science lesson, but only one of the three teachers being interviewed mentioned these two areas of concern. It was also intriguing to note that assessment and PCK were mentioned by some of the teachers responding to the survey but not highlighted as a major contributing area of difficulty when being creative in the interviews.

9.7 Considering why these teachers believe it is difficult for a child to be creative in the science classroom

Just as I did with the survey, I also wanted to attempt to discern more about the teachers' views of the issues and problems of developing children's individual creativity, so I also asked question 5 which can be cross referenced with question 13 of the survey.

The responses from question 5 (examined as described in section 9.6) are summarised in table 9.7 below.

Case A	Case B	Case C
• Lack of scientific ability • Lack of ability to think divergently	• Constraints of prescribed lesson plans • Lack of resources	• Fear of not knowing the correct answer/solution

Table 9. 7: A summary of the teachers' considerations regarding the challenges children face in developing creativity in science.

I found it intriguing that the teacher in case A appeared to believe that thinking in a scientific way was innate for some children but not for others. She stated, *'I think your pure scientist perhaps doesn't need the story [laughs] and you know just, just given a bowl of water will sit there quite happily devising experiments, but that's not most, most children.* She went on to say *'some of them will perhaps find a great difficulty in taking…a scientific fact and understanding it but others just… are very happy with it'.* The teacher uses this as a means to reinforce her reasoning behind her creative approach.

> '…we're asking them to think in a different way. We're asking to think of things as they've never done before. They've had a bath but they've never thought about how the level goes up when they get in. So the challenge for them is to put it into understanding and everyday terms…which makes the facts part of their lives'.

So, having considered this further does this mean that she believes a teacher can help facilitate creativity through the children's everyday experiences? This ability to be scientific will be addressed in greater depth in section 9.9 where I examine all three teachers' responses to the question, *'In your experience, are there some children that you believe would have more (or less) of an aptitude for creativity in science than others?'.*

The teacher in case B articulated her frustrations about the lack of resources available and how this can stifle a child's creative endeavours, *'…we haven't got unlimited resources, if a child asks me for a parachute and I haven't got a parachute how can I provide that for them'.* Perhaps this lack of resources could indicate why the majority of teachers, who answered the survey, felt they have to follow a planned lesson structure (see section 6.2.1.4). This resonated with the teacher, in case B, when she suggested prescribed lessons constrained creativity, *'I think… a lot of children are used to being told we're going to be doing this, this and this is how we're going to achieve our goal'*.

Fascinatingly, the teacher's response, from case C, to this fifth question also corresponded with the survey's most frequently cited reasons for children to find it difficult to be creative, these were, being fearful of getting the answer wrong and believing there was a correct answer to be sought. The teacher stated, *'I think some children see it [the experiment that goes wrong] as not working. You can't just go 'yeah, but that doesn't work', they've got to do it [i.e. find a solution]'.* She went on to justify an open-ended approach to experimentation by suggesting that *'a lot of children will learn from the actual physical-ness of it not actually going right'.* She strengthened this by referring to her perception of how past eminent scientists worked *'…if you think about all those amazing inventors [such as those mentioned within the literature review], if they gave up on the first go we'd be nowhere'*.

The next question I invited the teachers to answer was intended to cross reference with question 10 from the survey. The teachers were asked why being creative in other subject areas, other than science, may (or may not) be easier.

9.8 Notable accounts of creativity in other disciplines, not science

The subjects specifically mentioned by each teacher as being more creative than science can be found below in table 9.8

Case A	Case B	Case C
• Art • History • Literacy	• Art • Design and Technology (D&T) • Drama • History	• Art • Drama • Music

Table 9. 8: Disciplines (other than science, in alphabetical order) in which the three interviewees believe it's easier to be creative.

It was interesting that the teacher in case A highlighted the subjects she found it easier to be creative in, but she emphasised how everyone was different.

> 'I've always found it very easy to think through craft and making and that lead to art, to history and then to creative writing and um, and to science, it's all linked. Um (.) but I think that's my way in. I think children have different

> starting points… Somebody else would start with um er reading about it or writing about it'.

The example she provided reflected her own subjective experience of being creative through the arts and crafts and this reportedly helped her to be innovative in other subject areas, such as history, literacy and science. This ability to be more creative in the art subjects was something that was also mentioned by the teacher from case C, she stated, *'if perhaps you were more of an artist, which I am not, maybe you would find it easier to think creatively through art'*. She too recognised that an individual's background may play a part independent of the subject being taught.

> 'You know if you've done a lot of creative stuff personally and out of school time maybe you would find it easier to be more musical or be more artistic um. (.) So I suppose it depends on your, your sort of, you as a person really and what opportunities you've had in your training or in your teaching experience (.) that will influence (.) how you are in particular subjects'.

For example, this teacher had undergone continued professional development (CPD) in creative science and she acknowledged that this had had an effect on her creative practice.

> 'Interviewer: So you think you are more creative in science because of your training.
> Teacher: Yes, I would say so and actually as a sort of note to self really I think that it's really important that we look for opportunities in school for some in house CPD'

In contrast to cases A and C the teacher in case B did not mention individual background or training helping to augment creative practice. She suggested that it was easier to be creative in non-core subjects generally, as opposed to Numeracy and Literacy.

> 'I think it's easier in non-core subjects. It's easier than in Maths or English because Maths and English are your vehicle for producing your outcomes aren't they? So it might be, you might be writing to record, or you might be talking or doing drama whatever, but that's more the vehicle for the (.) expressing what you've done in the lesson. So I think things like History (.) and Geography and Art and you know D&T, you can be more creative'

I found it interesting that she appeared to place precedence on Numeracy and Literacy being the driving force (the '*vehicle'*) behind producing *'outcomes'* in primary education, no matter what the subject. For example, she believed that science (which is also a core subject but not mentioned above) reportedly relied on Numeracy, she went on to state that *'…you do use a lot of Maths in science, I don't think it's quite as easy to teach creatively in Maths'.* It could be inferred from this comment that she too believed it was harder to be innovative in science, rather than other non-core subjects, because of its mathematical grounding.

It was also intriguing that this teacher thought that literacy was possibly not a subject in which creativity could be easily developed (compared to other disciplines). This is contrary to the results from the survey chapter (see section 6.2.1.2.3) were it was cited as the most frequent subject in which teachers had observed children being at their most creative. It is notable that the teacher in case C did not refer to it as a creative subject. Nevertheless, similarities between the two data sets (interviews and survey) do occur. Referring back to table 9.8 it would appear that all three teachers connected creativity with subjects associated with the arts, including art, history and drama, and this is consistent with the results from the survey chapter. Thus I can reinforce my original findings from the survey, which were that teachers are persistently associating creativity with arts based subjects rather than subjects which involve Mathematical/logical procedures (e.g. Mathematics itself and ICT).

Earlier in section 9.7 I considered something the teacher in case A said about certain children having an innate ability to reason scientifically. This has led me to think about whether other teachers believed certain children may find working creatively in science more or less difficult. So I asked *'In your experience, are there some children that you believe would have more (or less) of an aptitude for creativity in science than others?'.* 'This question is not in the survey but case A's response in section 9.7 stimulated me to consider probing for further insights into the teachers' perceptions of influences on creativity.

9.9 The teachers' self-reported illustrations of children who have more (or less) of an aptitude for creativity in science

After examining the teachers' responses it was interesting to note that they identified particular types of learners as being less creative and these have been reported in table 9.9 below.

Case A	Case B	Case C
• Those with learning difficulties: such as, slow learners or those with severe learning difficulties	• Those with learning difficulties: such as, having low ability or those with a marked disability	• Those who are high-attainers

Table 9. 9: Interviewees' views about which kinds of learners are likely to be less creative.

As summarised in table 9.9 students with marked/severe learning disabilities and high academic attainers were perceived by the teachers as potentially less able at being creative. The context in which these beliefs are set is briefly examined below.

The teacher in case B described students with low abilities and learning disabilities as requiring further support or encouragement to think creatively,

> 'Children with a very low ability are not often as creative because they can't think outside the box very easily. So if you've got children with quite marked learning disability or learning difficulties they'd have to been shown how to be creative and then copy what you've done because they probably won't come up with ideas themselves'.

It is noted that the teacher omitted to specify what type of learning difficulty she was referring to or how she defined low ability. Nevertheless the teacher in case A seemingly concurred with this view when she stated, *'children who are slow learners who have difficulties, um, they need to be in smaller groups and very slower and controlled and directed [groupings]'.* The teacher went on to suggest that selecting who will join this group of carefully chosen children was important because *'…when you have a child who has severe learning difficulties with children who are very bright they um, tend to get ignored or make a disturbance. They can't all work at the same level'.* Whilst I believe that the teacher is referring to the various ways in which children can participate in group work when in a normal learning situation (not just when endeavouring to nurture creativity), I cannot be sure whether she is making reference to the high-attainer or the child with learning difficulties being ignored or causing a disturbance. The idea of high-attainers struggling with being creative was potentially indirectly highlighted in case A, but it was the teacher in case C who explicitly suggested that they may find being creative difficult, especially when involved in more open-ended tasks;

'…the children that are always used to being top of the class…don't always feel comfortable not knowing the [correct] answers. (.) They are not necessarily always good risk-takers….I have seen examples of children who have really struggled when things haven't gone the way they wanted them to (.) and I don't know if that's because they care more, or they like to know there is a [right] answer. I don't know why'.

Here the teacher mentions risk-taking being difficult for some *'top of the class'* children. It could be that, in the above example, she is not referring to these children as being less able to be creative but more reluctant, perhaps she perceives them as being more comfortable with received wisdom rather than developing their own personal scientific ideas or explanations.

Having discerned how the teachers believed they fostered the development of creativity through their science lessons and then having examined the difficulties they and the children faced (from the interviewee's perspective) my attention is now turned to how these teachers would go about assessing their pupils' on-going scientific learning and creative thinking. In the next section of this chapter I have endeavoured to clarify the nature of assessment strategies currently being employed in science lessons and how this is (or could be) adapted to assess creativity.

9.10 Reflecting on teacher approaches to formative assessment of creativity during their science lessons

Questions 9, 10 and 11 were specifically designed to elucidate how the three interviewees formatively assessed learning in science and whether (or not) they could adapt these strategies to judge their children's creativity. These responses also directly informed RQ3 of my thesis. This line of enquiry was also considered to cross reference with data collected from questions 15, 16 and 17 of the survey (see appendix 5.K). The questions asked during the interviews were:

9) How do you currently assess the children's progress in science?
10) How do you currently assess the development of creativity within your science lessons?
11) Are there any strategies that work better to assess creativity and why?

The teachers' responses to questions 9 were both inductively (as described in the methodology chapter, section 5.6.3.5.1) and deductively analysed (this framework described in the methodology chapter, section 5.6.1.6.3.2). The results of this bilateral scrutiny can be found below.

9.10.1 Illustrating the nature of the teachers' current assessment strategies in science

Initially I considered the teacher's verbal accounts to question 9 in light of Wiliam's (2011) five key strategies of formative assessment, these have already been examined in full in section 3.1-D.2 of the literature review, but I have provided them below.

1. 'Clarifying, sharing and understanding learning intentions and criteria for success
2. Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning.
3. Providing feedback that moves learning forward.
4. Activating learners as instructional resources for one another.
5. Activating learners as the owners of their own learning.'

(Wiliam, 2011:46)

The results of this analytical approach can be found in figure 9.1 below. It shows which of Wiliam's strategies are demonstrated through the teacher verbal accounts of assessment.

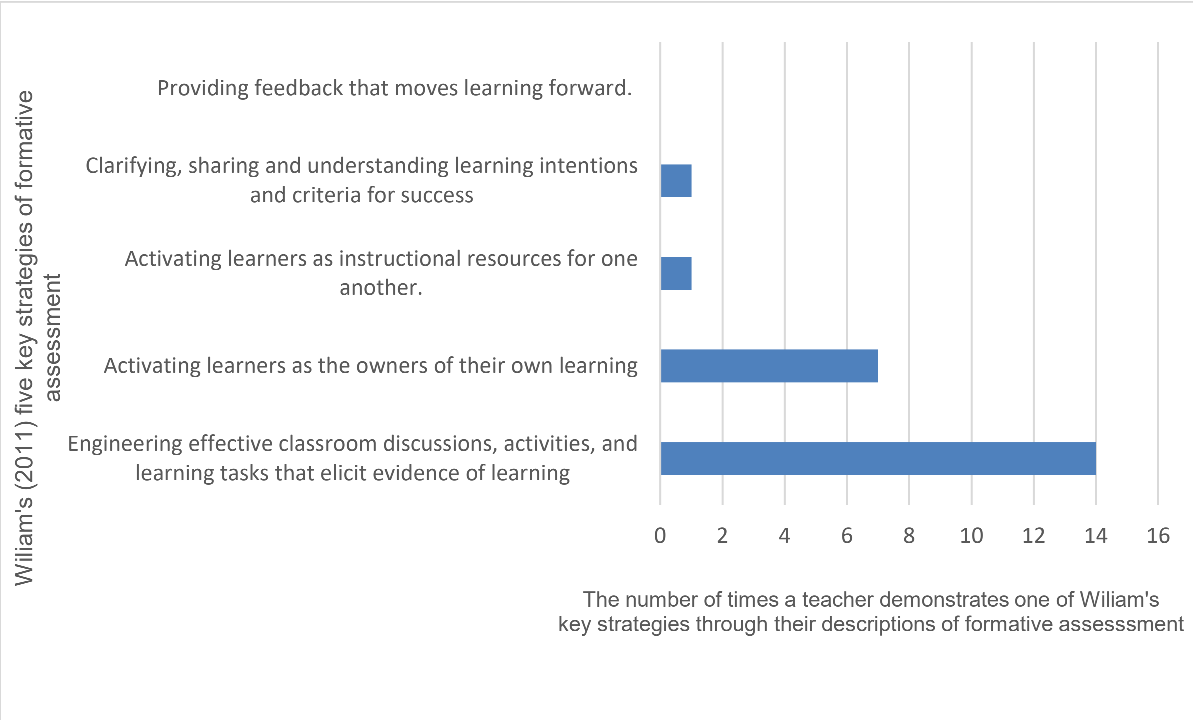


Figure 9. 1: Graph illustrating which of the five key Afl strategies the interviewees reported they used.

Similarly to question 15 of the survey, question 9 invited the teachers to describe the full range of assessment strategies employed when assessing pupils' learning in science. Thus all three teachers described the numerous techniques they used to elicit evidence of their pupils' learning. So perhaps unsurprisingly, the results were akin to the survey's findings (section 6.2.2.2) in that there were a substantially larger number of coded themes relating to Wiliam's second key strategy (n=14), i.e. the formative assessment techniques used were *effective in engineering discussions, activities and tasks that can elicit evidence of learning* (see figure 9.1).

To continue to correspond to the approach taken in chapter 6 of this thesis, so that I can triangulate results, I also wanted to clarify which techniques were evident in the primary science teachers' reported practice. Through this grounded analysis I discovered that all the teachers reportedly collected their pupils' evidence of learning through observations (n=3), classroom talk (n=3) and questioning (n=3). These three methods of evaluating the students' developing knowledge were also the assessment techniques of choice according to my findings from the survey data (section 6.2.2.2). Other methods mentioned briefly by the interviewees included written work, practical assessment and knowledge acquisition tests.

Following on from discovering the teachers' current assessment methods, I wanted to know how (or if) they had adapted these strategies to evaluate the children's developing creativity, so I asked question 10. Interestingly, the responses I received from two teachers' were similar to those elicited from the survey (section 6.2.2.2), that is the methods employed to assess creativity were, observations (n=2), questioning (n=2) and talk (n=2). However, there was an exception when one teacher seemed somewhat perplexed about my line of questioning, and stated, *'I mean, you can look at children and see if they are creative but how would you record that [creativity]'.* This response prompted me to question this teacher further by asking if she would consider any particular AfL strategies could in her opinion assess creativity (see question 11). The teacher responded,

> 'I can't see that it would be something beneficial to you to access. You can encourage children to work in that way but what would you assess?…[the teacher continues to express her doubts about assessing creativity]…should you reach a certain level of creativity? So what's the point of assessing it if you've not got a sort of level where you'd want the children to get to'.

Here the teacher appears to be questioning the usefulness of assessing pupil's creativity in science, and highlighting that fact that there is no levelled and hierarchical framework. It may be that she is referring to something akin to the assessing pupil's progress (APP) map. This APP map has been used by some schools to assess science to produce summative results (Turner *et al*, 2012); it contains a set of assessment guidelines that refers to a set of progression levels, from 1 to 8. These levels were defined by the National Curriculum for England and its associated level descriptions (Brodie, 2011). Other assessment strategies in science, which appear to have their roots tentatively based in the APP framework, have been trialed (Tyler, 2013) and I believe it is to this type of framework that she is referencing especially when she goes on to say, *'I can't see, you know, a creativity scale and I'm a 1 and you're a 6'.* This teacher is not the only person to try and construe (or imagine) the usefulness of a framework to analyse children's creative thinking (Robson, 2014). Robson stated that just such a '…framework [to assess creative thinking should] serve as a series of indicators rather than a list of ingredients…Individual episodes may generate examples from a number of the categories, or, in some cases, all of them' (ibid:130). Thus, even Robson was recognising that creativity could not be measured through a static list of consecutive progressive statements/levels. I believe this teacher concurred with Robson's (2014) concern when she stated *'I think it would be very difficult to assess it [creativity] because it is so individual'.*

An overarching grounded theme emerged from the responses to question 11: it appeared that successful assessment of creativity is through self and/or peer-assessment. One teacher described this approach aptly when she referred to an activity called the *'royal walk about'*.

> '…the royal family walk around art galleries and things and they stand with their hands around their back and they go 'um, yes, very interesting, very interesting'. We have the royal walk about and they walk around and they are not allowed to touch anybody else work, but they can look, they can ask other people questions about it. So I think it's opportunities for (.) showing what they've done creatively rather than writing it always down'.

Here the activity being verbally illustrated involved observation (looking at other's work/outcomes), questioning their peers (evaluation and review) and classroom talk. These findings resonate with the survey data indicating how these three methods of naturally embedded formative assessment have been (and are being) highlighted by teachers as the best ways to assess the children's creativity in the science classroom.

I have not found an example of this exact activity (the royal walk about) in formative assessment literature, but it is representative of what Wiliam (2011:133) called ‘activating students as instructional resources for one another’. This, according to Wiliam, is where learners help each other through collaborative and cooperative tasks. I have discussed this strategy further in section 3.1-D.2.4 of my literature review. Wiliam cites a study by Schacter (2000) in support of this type of peer-peer assessment. Schacter studied ‘109 [American] students in fourth-, fifth-, and sixth-grade classes…[he reported that] working in student-led groups [pupils] learned almost as much as students getting one-to-one tutorial instruction from a teacher, and those in student-led groups actually learned more than those in teacher-led groups’ (*ibid:*134). Wiliam (2011) even went on to state that,

> ‘…the benefits of cooperative learning environments are greater for lower achievers [for example, Boaler, 2002]; others have found benefits for high achievers [for example, Stevens & Slavin, 1995]. Overall, it appears that, as long as the two key features of group goals and individual accountability are present, cooperative learning is equally effective for students at all achievement levels (Slavin, Hurley, & Chamberlain, 2003)’ (*ibid:*135).

Therefore Wiliam is suggesting that this form of peer-peer assessment would temper the three teachers concerns about those who they perceive to be less able to be creative (see section 9.9). However, I had previously advised that having set goals and targets, such as those described by Wiliam in the quotation above, when trying to develop creativity, could limit the numerous possibilities that creative thinking might unpredictably proffer (see section 2.2-A.3.2). Thus this assessment strategy, as described by Wiliam, when trying to nurture subjective innovative thinking in the classroom may require further consideration.

The second part of question 11 also asked for a justification as to why the chosen assessment strategies may assess creative thinking, but unfortunately due to a lack of interviewer probing I was unable to discern how the teachers could (or did) adapt their chosen techniques to capture creativity-in-learning. However, by following the same analytical approach taken in the survey chapter, (which examined the responses for question 15, see section 6.2.2.2) it became clear that both teachers (who answered this final question) saw assessment as a way for the child (or children) to be agentive learners (i.e. it was the child who applied or initiated the AfL strategy). It is imperative to highlight here that this does not mean that the children are, in reality autonomous assessors, just that the teachers are reflectively describing the child as applying or initiating these assessment strategies for themselves.

9.10.2 Summarising teachers' descriptions of assessment in practice and how they could be adapted to capture creativity-in-learning

In summary, the teachers each acknowledged child independence or agency as pivotal when employing formative assessment strategies. There were numerous assessment techniques mentioned that are employed to elicit evidence of learning (n=14) and these provided ample opportunities for the children to express their original thinking or personal perspectives. However, the three techniques teachers recognised to be most appropriate to assess creativity were observation, talk and questioning. These findings resonate with those from the survey chapter. It is not clear, however, exactly what teachers would pay attention to within these quite broad categories to best capture 'evidence' (particularly of observation and talk) to illustrate the reification of creativity-in-learning.

Chapter 10

Reflecting on findings

10.1 Introduction

In a similar approach adapted from McMahon's (2010) doctoral thesis I have chosen to separate this chapter into two sections. Initially in section 10.2 I review my methodological approach and the methods I chose to employ when collecting and analysing data. This will be followed, in the second section (10.3), by my interpretive insights from the data. It is my intention that these findings will inform teachers' and fellow academics about what it is that a teacher does to promote and nurture creativity in primary school science lessons.

10.2 Reviewing my methodology to interpret my findings

As I described in the methodology chapter, during this research study I have endeavoured to become (and be) an interpretivist researcher, this is after over a decade of working within the parameters of a positivist paradigm (see section 5.3.1). This evolving paradigm shift has influenced the development of three methods of data collection (i.e. questioning teachers through a survey, observing science lessons and collating post-observational interviews); it has also helped me to develop subsequent ways (in an hermeneutic sense) to analyse the data gathered. However, as I progressed further within a social science environment, becoming more interpretivist, I have reflexively considered these research methods through my own developing anthropological perspectives, and subsequently realised how this may have affected aspects of my data collection and analysis. Therefore in this chapter I have elected to reflect upon the influence of the data collection approach on the outcomes of my study, which includes reconsideration of the connection between the research instruments, my raw data and my analytical frameworks before summarising my interpretive findings.

10.2.1 Reflecting on the collection and analysis of survey data

I highlighted, in the methodology chapter (section 5.6.1.1), that it was my intention that the survey would explore views of a wider population of teachers (n=101) so that their multiple understandings and use of creativity in the science classroom could be elicited. A copy of the questionnaire used for the survey can be found in appendix 5.C, and details of the approach adopted and the methods employed to analyse the data collected have previously been described in the methodology chapter, section 5.6.1.

The survey contained three sections (A-C), section A requested demographic data (i.e. gender, years of experience etc…), whilst section B sought to elicit and understand the ways that primary school teachers described and promoted creativity in their science classrooms. Finally section C explored how (or if indeed) the teachers formatively assessed creativity during science lessons. It is the way in which I analysed the data gathered from sections B and C that I reflect upon below, in sections 10.2.1.1 and 10.2.1.2 respectively.

10.2.1.1 Re-considering Ann Oliver's ten ways to make science teaching creative as an analytical framework

Self-reported episodes of creativity within science lessons, from the teachers' perspective, were interpreted through coding responses, the categories of which were adapted from Oliver's (2006) ten ways she suggested science teaching could be creative (see literature review, section 2.2-B.2.1 and appendix 6.A). The methodology chapter, section 5.6.1.6.2.2 and the results chapter 6, section 6.2.1.2, provide a detailed explanation of the way Oliver's ten categories were applied.

In post-analysis reflection, when considering the use of Oliver's ten categories (see table 10.1 below, first column), I realised they could be tacitly as well as subjectively misunderstood. For example, Oliver's full written description of her eighth category '*modelling explanations'* recognises how science can be visually presented (or modelled) in order for the children to understand (i.e. to make a connection to) something that is unfamiliar to them; but the word 'explanation' found in the original title is not clarified by Oliver's portrayal of this category. That is, Oliver does not adequately suggest how the teacher (or the child) should, in actuality, communicate or verbally express their understanding of the scientific phenomenon (this was originally explained in greater depth in section 2.2-B.2.1.8 of the literature review). Her use of it in the literature suggests more that she is concerned with imaginative ways to model scientific conceptions or understandings. Therefore, perhaps there should be a reconsideration of this category, so that its original descriptive meaning could be made more explicit. This would mean that it would be less likely to be misconstrued should it be re-labelled as something akin to '*visualising scientific concepts'* intended to concretise abstract scientific notions, like bacteria spreading, or UV light slowly affecting the properties of skin (activities that model both these scientific concepts have already been described by teachers answering the survey's questions in chapter 6). The reconceptualised title has also been placed into table 10.1 below, second column, next to Oliver's original heading. This new title resonates more aptly with Oliver's original explanation of this eighth category and associates it with an investigation which would have been deemed to be a creative classroom activity (CCA). An example of which could include, discovering what makes the best curtain material for an insomniac mouse, as described in chapter 7, section 7.1. This particular activity would have been, according to the NACCCE's (1999:102) an apt illustration of teaching creatively.

Whilst examining the teachers written descriptions of creativity I also re-developed Oliver's categories to try and elucidate whether it was the teacher or the pupil who was more agentive in the creative activity. That is, the written reports of creative episodes were coded into bilateral categories, where discernible, and classified as either teacher-initiated or child-initiated creativity (i.e. as TIC or CIC respectively). It is with this in mind that I have, post my original analysis, suggested two different headings for the eighth category which reflect these two approaches. Thus, when the teacher attempts to illustrate a scientific concept through abstract real-world examples they could be *'demonstrating science concepts through visual exemplars'* (this could represent TIC), and when a child visualises the scientific in a similar way it will, according to Taber (2012), afford them the opportunity to use their thinking skills to *'generate/discern their own subjective visualisation of a scientific idea*' (this aptly illustrates CIC). Both of these adjusted and slightly re-conceptualised titles can be found in table 10.1 below.

In the same table (10.1) I have also suggested other CCA headings, which are reflexively informed by my post analysis review of Oliver's ten categories, because these too were problematic when delineating all types of creative classroom activities. Within each category I also propose ways of considering the teacher (TIC) or child (CIC) agency within each type of creativity.

In a similar approach to my literature review, when I originally considered Oliver's ten categories (in section 2.2-B.2.1), I will, in table 10.1, consider a refreshed honing of each of these categories in line with Davies's (2011) description of creative teaching. To briefly reiterate, Davies's description of teaching creatively (TC) focuses on the teacher's ability to communicate or convey science in a creative way, whilst teaching for creativity (T4C) defines the teacher as *supporting* the children to express and develop *their* own creativity. There are situations where either (or both) TC and T4C can be construed and I have subsequently attempted to clarify that through the adapted categories, when exemplified through the headings in table 10.1 (below).

Ann Oliver's ten way to make science teaching creative (Oliver, 2006:25-35)	Reconsideration of the category to make its focus more explicit (CCA)	Category title adapted to represent teacher-initiated creativity (TIC)	Category title adapted to represent child-initiated creativity (CIC)
Turning the predictable into something better	Making the common place intriguing, by not following a prescribed (or well-known and established route/method).	Using the predictable (or the familiar) to challenge thinking. For example, resourcing an investigation into what makes the best curtain material for an insomniac mouse (TC). An example of this activity can be found in chapter 7, section 7.1	Considering the everyday from different perspectives. For example, the children could investigate their own natural surroundings to construe what materials would create the best curtain material.
Making the ordinary fascinating	Considering science through everyday objects and phenomena to stimulate interest	Demonstrating familiar objects (or phenomena) to connect to the [scientifically] unfamiliar (TC). For example, magnifying insects and plants to discern what is unobservable with the naked eye or observing what happens when different coloured M&M's are placed in a plate full of water.	Taking ordinary everyday things and 'seeing' them differently, i.e. the children attempt to explain the scientifically unfamiliar.
Sharing a sense of wonder	Developing and disseminating a sense of amazement at the surrounding environment and world.	Highlighting (verbally or visually) the extraordinary from within the ordinary (TC). For instance, drawing attention to something the children may miss, e.g. the fact that ice, which is solid, floats.	Spontaneously examining and/or exploring the extraordinary from within their ordinary. Reified through exclamations *wonder*, followed by their subjective explanations of *why.*

Seeing differently	Allowing different perspectives to be considered *(so that fresh perceptions can be reciprocally discerned and/or considered).*	Affording the opportunity for the learner(s) to discern science from another perspective. For example, inviting children to think about why they believe a spider has built a web on a particular shrub/wall? (T4C)	Children actively partaking in scientific endeavour. For example, I observed a year 1 boy placing two pieces of charcoal on the ends of a forked twig. He then placed one of the pieces of charcoal in a stream to see which would disintegrate quicker.
Maximising opportune moments	Highlighting how the scientific relates to everyday phenomena, or inviting the children to make suggestions about how the commonplace relates to the scientific. .	Inviting children to think about where science occurs in everyday life (TC and T4C). This can include watching boiling water turn to steam, as an egg (placed inside the water) changes from a runny consistency to solid.	Expressing alternative ideas and/or solutions to observed scientific phenomenon.
Humanising Science	Appreciating how human endeavours have generated understanding about science	Presenting ways (e.g. through stories or drama) (TC) so that children can 'see' how humans have changed what we understand about the world around us (T4C)	Participating in scientific endeavours to experience (and even employ) the qualities of a scientist. Akin the year 1 boy discerning which of the pieces of charcoal would dissolve more quickly.
Valuing questions	Raising, identifying and celebrating good (appropriate) scientific questions	Presenting or posing questions and giving value to those raised by the children (TC)	Children raise their own questions and identify good scientific questions
Modelling explanations	Visualising or concretising scientific concepts	Demonstrating science concepts through visual exemplars (TC). An example includes the aforementioned investigation in what makes the best curtain material.	Generating/unique or personally subjective visualisations of a scientific idea.

Encouraging autonomy	Encouraging independent play and exploration/agency	Encouraging agency, through mediatory practices (TC and possibly T4C)	Independently making decisions whilst exploring and playing.
Allowing for flexible beginnings	Initiating opportunities for children to engage creatively and think differently. The teacher only intervening if necessary.	The teacher's mediatory practices were realised through the ninth category, *encouraging autonomy/agency*. Thus similarly to Davies and McGregor (2017) I have chosen not to define this final category.	

Table 10. 1: A re-considered and somewhat re-conceptualised version of Ann Oliver's ten ways to make science teaching creative to encourage children's creativity

Reflecting on Oliver's ten categories, they appear to be focused on classifying ways of making explicit CCA, not specifically identifying **all** the different ways a teacher could pedagogically support originality/innovation, or indeed capture all the reifications of creativity that a child might proffer. The way that I applied Oliver's categories renders explicit an assumption that TC and T4C are only interpreted as occurring when the teacher initiates creativity (TIC). Additionally, it is also discernible that when TIC is designated as being TC, in table 10.1, the teacher was interpreted as demonstrating/communicating the science to the children. However, effective T4C is when teachers appear to actively provide the opportunity for the children to independently pursue ideas and/or make connections to the scientific. This resonates with Davies's (2011) description of creative teaching. With Jeffrey and Craft's (2004:85) suggestion that 'the former [TC] is often inherent in the latter [T4C] and the former frequently (but not always) leads directly to the latter, a *continuum* of classroom creativity could be assumed and construed from table 10.1 (see figure 10.1 below).

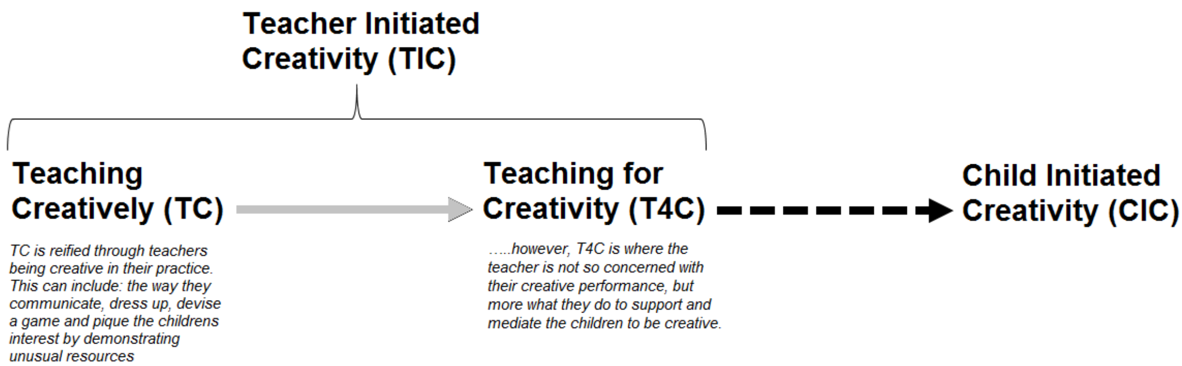


Figure 10. 1: A continuum of classroom creativity (from teaching to learning)

Notice how the two components of creative teaching (TC and T4C) are represented as taking place, on figure 10.1, when the teacher is being creative (TIC), just as indicated in table 10.1. Jeffrey and Craft's (2004) suggestion of the former (TC) being dependent on the latter (T4C) is also illustrated on figure 10.1 through the grey (faded) unidirectional arrow. However, when the child is agentive and produces something creative independently of the teacher (CIC), it is they who initiate the original thought, suggestion or action rather than respond to the teacher's question or instruction. For example, you may recollect the year 6 pupil who was thinking creatively when she decided to recharge her flat battery with static electricity, by rubbing it against the carpeted floor (see literature review, section 2.2-A.2), she was, at this juncture, thinking independently, through an activity that had been resourced by the teacher. Figure 10.1 illustrates a possible transition between TIC and CIC, as a dashed line because it is not something that consistently happens (as would be represented by a continuous line). In this diagram I am striving to indicate how TIC can provide the environment for children to develop agentive CIC.

Having suggested a re-conceptualisation of the headings of Oliver's categories, to make them more explicit (as TIC or CIC) in their meaning, I also want to refer back to section 2.2-B.2.2 of the literature review, where Davies (2011) suggested that Oliver's ten categories identified *some* of the characteristics of creative teaching. I took this comment to indicate that the development of creativity could not always be fully realised through discrete or multiple predefined categories, such as those in table 10.1. This brings to mind something Lipman (2003) said when contemplating his list of twelve descriptors of creative thinking (these are originally outlined in the literature review, section 2.2-A.3), he stated:

> 'There was nothing magical about the limitation of this list of twelve characteristics [of creativity]; obviously, there could be many more or many less. What would be useful to learn would be the extent to which the items listed are summaries of….creative thinking' (ibid:247).

Whilst Lipman is referring to attributes of creativity (not teaching) in this quotation, I believe that the notion of there being many more, or many less, features of creative teaching resonates. For example my fresh interpretation of Oliver's *seeing differently* and *humanising science* appear to be similar (through both TIC and CIC sub-categories) thus in retrospect these may need even further consideration to develop a comprehensive list of TIC and CIC generalisable characteristics illustrating creativity. Furthermore, in the results chapters (i.e. 7, 8 and 9) I had argued that adopting a risk-taking behaviour (i.e. critically challenging the children's ideas) could help learners to consider and evaluate their personalised thinking (and outcomes). This teaching approach which can encourage children to feel unconstrained in their thinking and take a gamble, I have argued, is an integral part of T4C and therefore should also be considered a facet of creative teaching, in addition to those found in table 10.1.

By considering Lipman's (2003) quotation above further, I too suggest that it would be useful to examine, perhaps through additional research studies, the extent to which the current listed TIC and CIC bilateral categories, in table 10.1, inform both creative teaching *and* creativity that emerges in learning. I believe this could be done whilst simultaneously considering the aspects that may have been omitted (e.g. the adoption of risk-taking behaviour).

10.2.1.2 Re-visiting the analytical framework adapted from Wiliam's five key strategies of formative assessment

Following on from considering aspects of my analytical framework, designed to examine data from section B, I also wanted to reflect upon the way in which I analysed the data collected from section C. That is, the section where I explored whether (and how) the teachers formatively assessed creativity during science lessons. Initially I conceptualised an analytical framework with Wiliam's (2011) five key strategies of formative assessment in mind (see section 3.1-D.2 of the literature review). This was originally designed to discern, from the teachers' descriptions of assessment-in-practice if, and, how they met the formative learning needs of the pupils.

However, the responses examined from the survey only invited the teachers to describe the range of assessment strategies they employed and not how or why they chose to employ them. I was therefore, post-analysis, left with lists of multiple techniques that teachers reported they used to elucidate evidence of learning and I had to acknowledge that I was unable to examine exactly *how* the formative assessment techniques were being employed in classrooms. In chapter 6 there is a greater explanation as to why this occurred (see section 6.2.2.2). I hoped that subsequent observations (reflected upon in the next section) and post-observational interviews (see section 10.2.3) would help distinguish the extent to which teachers' believed they were (and in reality appeared to be) assessing creativity in their science lessons.

10.2.2 Re-considering the observational data collected with the research tools employed

As well as surveying teachers I chose to observe where creativity was evident in science lessons (through cases A-C), the results of which can be found in chapter 7 of this thesis. I did this because it had been reported that there was little correlation between the teachers' espoused views of their practices and what was, in actuality, happening (Johnston, 2007) from an observer's perspective. Unfortunately I was unable to directly cross-examine survey data with the three cases I observed, so the teachers were invited to take part in post-observational interviews, their responses were then triangulated with the survey (see appendix 5.K).

I chose to analyse my observation data by employing more than one analytical method, this is because, as I stated in the methodology chapter, 'each practice makes the world visible in a different way' (Denzin and Lincoln, 1994:4) and this also allowed for any discrepancies to be pursued (Scott, 1996). With this in mind I decided to illuminate where and how creativity was evident through four different means. They were:

1) Through analysing all of the teacher's questions, by means of a revised version of Wragg and Brown's (2001) and Brown and Edmondson's (1984) taxonomy of questions. This is described in more depth in the methodology chapter, section 5.6.2.3.
2) Via an observational schema which examined generalisable characteristics of a teacher's practice, on a minute-by-minute basis, through three particular lenses: i.e. when the teacher encouraged autonomy (or learner agency), took risks themselves and supported the generation of imaginative alternate ideas or ways of 'seeing' things and finally, when they verbally interacted with their pupils. The results of which was subsequently displayed graphically (see chapter 7, sections 7.4-7.6). This research tool, and its development, is described in greater detail in the methodology chapter (section 5.6.2).
3) By generating a timeline of mapped events for each case; these displayed the affordances that were made present during the science lesson by the teacher minute-by-minute. Created by considering Mercer and Hodgkinson's (2009) work and other ways of displaying classroom data graphically (Mortimer *et al*, 2015). This is described in more depth in section 5.6.2.7 of the methodology.
4) Then finally, by inspecting five particular verbal exchanges, per case, that were notable for the way in which the speakers articulated what they were doing and how these utterances were received by their pupils. These were examined to clarify how the exchanges were pivotal in reifying (or not) creativity. This examination was achieved through a newly conceptualised framework which combined Mercer's (2008) three types of talk (disputational, cumulative and exploratory) with Alexander's (2008) lesser-known five patterns of teacher talk (rote, recitation, instruction, discussion and dialogue). This is described in the literature review (section 2.2-B.1.1.2) and in the methodology chapter (section 5.6.2.6).

The development of each of these adopted methods of analysis is also briefly summarised in the introduction chapter of this thesis (section 1.2).

Throughout the observational results chapters (7-8) I have reflected upon the limitations of some of these analytical methods, for example I acknowledge that focusing on the analysis of questions would not capture all the possible open-ended conversations (Hardman, 2008) or understand when or how the teacher afforded the children the opportunity to be creative through their engagement in particular tasks. This was one of the main reasons why I subsequently chose to develop an observational framework which enabled me to discern how (and at which pivotal points during the science lesson) the teacher was promoting or (potentially) providing formative feedback to encourage creativity. The devised observational schema can be found in the methodology chapter, section 5.6.2.4 (table 5.4), but because I wish to reflect upon this further I have also displayed it below (see table 10.2).

Teacher Intentions	Teacher Actions
Monitoring factual knowing or recall of subject matter	Questioning to check understanding in a different contexts.
	Questioning the ability to demonstrate subjective/personal understandings.
	Questioning prior knowledge to demonstrate task specific understanding.
Offering opportunities for learners to generate original ideas	Suggests a range of new novel ideas for learners/children to contemplate.
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them.
	Drawing on prior knowledge to enable the learners/children to look at things differently.
Evaluating the thinking and creativity that may have arisen during the lessons/learning	Asks children to critically and/or creatively reflect upon ideas and performance.
	Asks children to reflect on ideas and performances/outcomes from learning (task-led).
	Teacher articulates their reflections on learners/children's potential ideas (task-led).

Table 10. 2: A Teaching practice schema: Characterising teacher actions within a science lesson

Teaching for Creativity | Teaching Creatively | Expositional Teaching

Key to table 10.2 above: Colours depicting the teaching practice to which the teacher intentions are associated

Whilst the graphical representations which were generated from the observational framework (chapter 7, sections 7.4-7.6) provided an illustration of the teachers' adopted practices through three theoretical lenses, I recognised that this type of observational framework still fell short of illuminating the actual affordances the teacher made available to promote agentive creativity; thus events maps were generated for each science lesson observed (see figures 7.11a-b – 7.13a-b, in section 7.7 of chapter 7). However, it was through the final means of analysis, where I examined the nature of teacher-child interactions through a newly conceptualised theoretical framework (see section 2.2-B.1.1.2, table 2.1), that I noted inconsistences between observational findings. For example, in chapter 8, section 8.3.2, I mentioned how it became discernible, through the examination of the transcripts, that I had interpreted both TC and T4C as taking place when the children, not the teacher, were taking risks (it was my intention that the teachers actions were examined through the application of the schema, not the learners). Additionally, I also acknowledged that the way in which I originally interpreted/described the teacher's actions through my observational framework (table 10.2) did not go far enough to illuminate when Fisher's (2001) critico-creative practices were reified. For example, the verbal exchanges taking place in excerpt 8.7 (section 8.3.2) were freely (and creatively) articulated by both TA and children (designated as being T4C through table 10.2) but they were not critically evaluated, thus creativity-in-learning was not explicitly expressed. As a result of this finding I had previously suggested, in chapter 8, that the teacher's actions associated with TC and T4C for the third evaluative category of the schema, (see the third row on table 10.2), should be changed to: *'the teacher critically and creatively reflects upon the pupils' ideas',* and, *'the teacher invites the children to critically and creatively reflect upon (their or others) ideas and performance'* respectively. This should then focus on the teacher's practices (not the children's actions) and it will also more aptly resonate with Davies's (2011:114) description of creative teaching.

Having recommended reviewing the descriptors for the teacher's actions on the observational framework for the third teacher intention (i.e. the evaluation of ideas) I wondered if the same revision of the first two teacher intentions (i.e. monitoring factual knowing or recall of subject matter, first row, and offering opportunities for learners to generate original ideas, second row) may also be required to ensure that the teacher's actions, not the pupils, were reflected through the generalised descriptions. With this in mind I have reconceptualised table 10.2 above, which depicts the observational schema as applied to the three cases (A-C) in chapter 7, to more aptly resonate with Davies's (2011) description of creative teaching (see table 10.3 below).

Teacher Intentions	Teacher Actions
Monitoring factual knowing or recall of subject matter	Questioning the children to enable them to articulate their developing understanding through different contexts (i.e. reciprocally consider other perspectives)
	Asking questions to creatively gauge the children's subjective/personal understanding
	Questioning prior knowledge to demonstrate task specific understanding.
Offering opportunities for learners to generate original ideas	Suggests a range of new novel ideas for learners/children to reciprocally consider and contemplate.
	The teacher shares/elicits alternative ideas from the learners/children and then forms links to expand upon them.
	The teacher draws on prior knowledge to enable the learners/children to look at things differently.
Evaluating the thinking and creativity that may have arisen during the lessons/learning	Invites children to critically and creatively reflect upon (their or others) ideas and performance.
	The teacher critically and creatively reflects upon the pupils' ideas.
	The teacher articulates their reflections on learners/children's potential ideas and actions related to the task engaged with.

Table 10. 3: The Teaching practice schema: Characterising teacher actions within a science lesson with Davies' (2011) definition of creative teaching in mind.

Teaching for Creativity	Teaching Creatively	Expositional Teaching

Key to table 10.3 above: Colours depicting the teaching practice to which the teacher intentions are associated

Notice how, in table 10.3, the teachers actions focus on their performance when expositional or TC, or they seek to actively involve the children when T4C. Having now changed the descriptors of my observational schema, I have subsequently reconsidered the five verbal interactions examined for case C (chapter 8, section 8.4). The teacher's practice, from case C, could arguably be designated as T4C through TC, because the focus was on the learners' articulating their creative ideas (expressing T4C) through the teacher-initiated activities (i.e. the teacher is TC), however if I were to employ my reconceptualised observational framework (table 10.3), then, potentially, only TC could be illuminated. I am suggesting this because my interpretation of the five excerpts examined in chapter 8 (sections 8.4.1-8.4.6) indicated that it was the teacher verbally reflecting upon the children's idea (i.e. she is articulating her own critico-creative practices) without the children being invited to engage in the same kind of reflection.

Even if I were to reanalyse my data by applying the new conceptualised observational framework (i.e. table 10.3) I have to acknowledge that when originally collecting observational data I, like McMahon (2010), did not managed to capture the whole class on camera, and for the majority of time the camera (and audio equipment) was focused on (and recording) what the teacher was saying and doing, not which (or how) children were participating in the verbal exchanges. Additionally, the manner in which I collected and subsequently analysed my data took no account of which children (or collective groups of children) were working together and contributing to the task at hand. There is literature that exists that examines how children interact with one another (Lemke, 1990, Littleton and Mercer, 2013) and my proposed model of the types of verbal interactions available in the classroom (i.e. table 2.1 in the literature review, section 2.2-B.1.1.2) has been conceptualised with child-child interactions in mind, thus further analysis of peer group (verbal) interactions (audio and/or video) could/should be examined to gain insights into how children support each other (i.e. collaborate) in the science classroom to become creative.

10.2.3 Reflecting on the interviews processes and reconsidering the data analysis

Having reflected upon how both the survey and observational data was collected and then subsequently deliberated upon the devised analytical frameworks I now turn to my third method of data collection (i.e. the post-observation interviews).

The three previously observed teachers (cases A-C) were invited to answer interview questions that were triangulated with those of the survey (see appendix 5.K). The teachers responses were examined both deductively (using both classification systems devised to analyse the survey data, as described above in section 10.2.1) and inductively (through a grounded approach, as described in the methodology chapter, section 5.6.3.5.1). I chose to employ this two-pronged approach because, as Glasser and Strauss (2006) stated, some things can be overlooked or discounted by applying logically deduced theories. The findings from these interviews can be found in chapter 9 of this thesis.

The deductive and inductive examinations of the responses from the interviews proved successful in highlighting the limitations of collecting data through the written format, because the teachers were perceivably more able to verbally articulate the difference between teacher and child-initiated creativity (see sections 9.4.1-9.4.2). That is, I was able to discern who was agentive from the teachers' reflective descriptions. This was contrary to the written accounts of creativity in chapter 6, where the teachers' portrayals of creativity focused on the innovation or novelty of activities, rather than clearly delineating between TIC and CIC (see section 6.2.1.2.5). I will examine this phenomenon in further depth in section 10.3.1.

The additional inductive examination of interview data proved pivotal, as Glasser and Strauss predicted it would, because it illuminated how the deductive analytical framework, adapted from Ann Oliver's (2006) ten ways to make science teaching creative, omitted aspects of a teacher's creative practice. That is, the interviews revealed how two teachers believe they augmented creativity by challenging the children's alternative ideas and suggestions, in other words, they perceived themselves as taking risks (see section 9.5). Thus my conjecture, in section 10.2.1.1, about considering additional/other aspects of creative teaching and learning to add to the reconceptualised list of creative characteristics (see table 10.1) is supported through these interview findings.

10.2.4 Reviewing the analytical approach

I have, in the three sections above, considered each method of analysis separately and highlighted their limitations, and whilst this has illuminated areas that need further consideration, such as the reconceptualisation of Oliver's ten categories (table 10.1) and the rephrasing of my observational schema (table 10.3), the validity of any findings construed and claims made through these individual methods has not been neglected. This has occurred because of my choice to employ more than one practice to successfully triangulate (and reflect upon) my interpretative discoveries (Denzin and Lincoln, 1994).

10.3 Insights into the ways teachers promote creativity during primary science lessons

My methodological approach and its effect on the on-going development of my research methods has been deliberated upon above, in sections 10.2.1-10.2.3. In the next section I consolidate the insights garnered from the data collected, as interpreted through my research tools. I endeavour to achieve this by directly answering my four research questions (RQ) in ascending numerical order; these were originally described in the methodology chapter section 5.4 and can be found *italicised* within the following sections (10.3.1-10.3.4)

10.3.1 Elucidating teachers descriptions of the ways they think they promote creativity in science

It was in chapter 2 of the literature review (section 2.2-B.2) that I described how there was limited source material about the provision of developing creativity through creative teaching. I attempted to extend this lack of literature by examining Oliver's (2006) ten ways to make science teaching creative through Davies's (2011) descriptions of both TC and T4C (section 2.2-B.2.1). I originally did this because Oliver had claimed that her ten categories augmented creative teaching but then omitted to mention how this practice was composed of TC and T4C. Through a classification system adapted from this examination of Oliver's ten categories (see methodology chapter 5.6.1.6.2.2) I attempted to discern '*how teachers described and promoted creativity in the primary science classroom?'.* It was intended that this analytical framework would not only reveal aspects of their practice but also discern whether teachers described themselves as initiating creativity (TIC), or as enabling the learners to be agentive in their own creative efforts (i.e. CIC); this would address my first RQ (which is *italicised* above).

To achieve this I invited teachers (through both survey and interviews) to explain their reflective views of their creative practice, and the ways that they thought children could develop personal and collective creativity through them. I did this whilst simultaneously inviting the teachers to provide examples of when (and how) they employed these activities. The development of the analytical methods used to examine the data collected, to respond to my first RQ, have already been revealed (and discussed further) in this chapter (section 10.2.1.1) and the findings from this examination can be found in chapters 6 and 9 (these are the survey and interview results respectively) of this thesis.

In essence, the findings from the survey revealed that the four most prevalent ways for a teacher to make science creative were by making the ordinary fascinating, modelling explanations, seeing differently and encouraging autonomy (as summarised in chapter 6). That is, the teachers were reportedly promoting creativity by employing naturally occurring everyday phenomena, to build a relationship with the scientific through the use of demonstrations and analogies, which, in turn, provided the children with opportunities to discern the world from another vantage point. This was achieved through the teachers facilitating open-ended investigations, initiated by the adults but subsequently controlled by the learners. This abridged explanation of chapter 6 findings has been triangulated and further validated through the deductive results elucidated from the three post-observational interviews (see chapter 9, sections 9.4-9.5).

It has been fascinating to discover that other researchers have also previously observed teachers using the learner's everyday experiences as a starting point to learn science (Na and Song, 2013; Sikoyo and Jacklin, 2009). It was these interactions, with the everyday, that Na and Song (2013) suggested helped the children consider their subjective ideas (or scientific notions) from another perspective. Viewing of the concept from an alternative stance also reportedly assisted the children when independently exploring and cognitively rebutting their own or other scientific positions (*ibid*). Whilst this description directly resonates with my findings the teachers in my study also reportedly used visual exemplars to model scientific concepts to teach science, but it was Niebert *et al* (2012) who warned against using these demonstrations unless directly associated with 'the children's everyday experiences' (*ibid*:849), and this was something the teachers, in my study, perceived themselves as doing. This interlacing between categories only serves to represent how each of Oliver's categories were (and are) intertwined and this is perhaps why so many of the teacher's self-reported descriptions of creativity were originally classified into more than one of the ten classification groupings (see appendices 6.B-6.E).

It has also been very interesting to triangulate the findings from the above deductive approach with that of the outcomes from the inductive analysis of interview data. These one-to-one consultations elucidated how two teachers believed they augmented creativity by challenging the children's alternative ideas and suggestions (see section 9.5 of chapter 9), an aspect of creative teaching that my original deductive framework had omitted (this has previously been referred to in section 10.2.3 of this chapter). There are further studies that have already referred to the importance of challenging the children's ideas through teacher-child exchanges in science, including Kerawalla *et al's* (2012) research, and then there are others who recognise the need for teachers 'to progress…[from] simply engaging and exploring the students' ideas to supporting them to develop clear explanations and scientific reasons for their findings' (Smith and Hackling, 2016:171). However, none have directly referred to this evaluative way of elucidating further thoughts as taking risks, nor did they associate it with developing creativity. Whilst Cremin *et al* (2013) has claimed that a teacher who takes risks is flexible enough to respond appropriately to alternative ideas, how a teacher was to be suitably reflective, when critically reflecting upon the children's ideas has not been reified (and unfortunately, thus far, I have been unsuccessful in illuminating this in my study, see chapter 8). Nevertheless, I have suggested that this critico-creative practice is achievable through exploratory dialogue (see literature review, section 2.2-B.1.1.2).

Both the deductive and inductive approaches provided a platform from which to understand what the teacher was doing to support the development of creativity in their science lesson(s) but, if you recall, I also wanted to understand who the teacher perceived to be the agentive developer of creativity (the teacher and/or the child). It was interesting to note that the majority of the written accounts (from the survey) could neither be associated with teacher or child-initiated creativity. I went on to consider what this meant: were the teachers unaware of the distinction between TC and T4C or could they instinctively recognise their mutual compatibility? Or was it not important to the teachers whom the source of originality or imaginative proposition was? It was fascinating to realise that during the interviews of case A, B and C, they each appeared to be able to distinguish between TC and T4C (see sections 9.3.1-9.3.3); thus I have had to acknowledge that the wide spread lack of differentiation between these two practices, within the teachers' written responses, could have been a limitation of the survey as a data collection tool, and not a deficit of teachers penned accounts noting differences between teaching creatively and creativity-in-learning.

10.3.2 Highlighting observations of key features or characteristics of teaching that support the development of creativity

My initial description of risk-taking as a possible behavioural characteristic belonging to a teacher, who is endeavouring to promote and develop creativity in science, was originally described in chapter 2 of the literature review (section 2.2-B.1.1.3). This trait has been linked to the child's ability to be agentive, by Cremin *et al* (2013), see section 2.2-B.1.1.4 of the literature review, and I have highlighted this connection (between autonomy and risk-taking) in chapter 7 when reporting upon the results of the observations. It was in chapter 7 that I considered further how learning manifests and develops between what the child is capable of doing for themselves (independently) and what they were only able to do with the help of others (i.e. with a more capable other), this is otherwise known as Vygotsky's zone of proximal development (ZPD). With this in mind I realised that the reification of the child's ZPD required the agency of the pupil to be articulated, I theorised that this may need to be actively encouraged by the teacher for it to verbally emerge. I conjectured further and acknowledged that for the child's on-going learning to become explicit the teacher may need to challenge the pupils' thinking (take-risks). Thus, it was in chapter 7, that I found myself beginning to answer my second RQ, (i.e. '*What appear, from researcher observations, to be key features or characteristics of teaching to support creativity?')* in greater depth, rather than just simply applying the schema (table 10.2) and then illustrating when distinctive features of the teacher's practices, (through expositional teaching, TC and T4C) were evident.

Whilst I have deliberated upon two facets of creative practice (encouraging autonomy or agency and risk-taking) and how these augment the reification of the ZPD, I have found myself also considering further *how* creativity can emerge through the verbal interactions taking place between teacher and child, and this consideration has proved pivotal for my research. It has been theorised, in the literature review (section 2.2-B.1.1.2), that this can be reified through exploratory interactions (Mercer, 2008) which illuminates the extent of the

ZPD and ultimately creativity-in-learning. This proved fortunate as I had, thanks to an inductive examination of five key pieces of literature, previously decided to examine when any and all teacher-child exchanges had taken place, through the devised observational schema (see section 5.6.2.4.1 of the methodology chapter).

Thus far, in this section, I have reasoned that the encouragement of autonomy (i.e. agentive learning), risk-taking behaviour (the challenging of articulated ideas) and social interactions are all contributing and observable characteristics of a teaching practice that support the development of creativity in the primary science classroom. When these occurred during the science lesson, in what minutes, they were illustrated graphically (see figures 7.2-7.10, in chapter 7), however these visual depictions of the teacher's practices did not elucidate the types of task undertaken, and whether or not the activities employed were teacher or child-led. To rectify this I have displayed all the activities employed in each of the three lesson as and when they occurred, per case, on an events map (see figures 7.11a-b, 7.12a-b and 7.13a-b, in chapter 7 respectively). The events maps then display who took agentive control of the activities through written descriptions of teacher/learner actions rendering the source of creativity more salient. Who is agentive within a learning task is important because, as I have already stated, independence of mind is an essential component if the learner is to traverse and extend their own ZPD. I believe that if the activity is continually directed by the more experienced other (e.g. the teacher in case A, who demonstrated her unusual objects whilst the children sat and attentively listened) there will be little (or limited) opportunity for learners to make explicit their creativity-in-learning. In contrast to this case C's events map (figure 7.13a) involves tasks that the teacher employed to enable children to articulate their subjectively creative ideas, which were critically challenged by her through further questioning. How these challenges are subsequently pursued, and whether creativity-in-learning was illuminated through them, is examined in further depth in chapter 8 (section 8.4). This is also discussed further in section 10.3.4 below.

10.3.3 Demonstrating how teachers report they currently formatively assess creativity

I have conjectured that teachers can assess the child's developing learning through encouraging and challenging their vocalised thoughts and ideas, and it is this that I have theorised can audibly capture a reification of the child's ZPD and creativity-in-learning. However, before exploring this further I want to examine how teachers perceived they currently assess creativity during their science lessons. Teachers were invited to respond to my survey and interview questions by describing the way they currently assessed learning and the children's creative thinking (see sections 5.6.1.3.3 and 5.6.3.2 of the methodology chapter). These responses have helped me to answer my third RQ, that is, *'Can teachers' descriptions of formative assessment-in-practice elucidate how they (could or already do) provide opportunities to assess creativity-in-learning?'*

The findings from the survey can be found in chapter 6 (section 6.2.2.2 onwards) and the outcome of my examination from the interview data is in chapter 9 (section 9.10 onwards). Those teachers who responded to my survey and interview questions provided various lists of numerous (and diverse) strategies which they employed to gauge learning formatively, and the majority referred to classroom talk, questioning and observations as their main method by which they collected evidence. They also confirmed that these three techniques were their preferred approaches to assess creativity. This is consistent with the results of a study of PSQM data, by Earle (2014), a study originally described in the literature review, section 3.1-C.3. Additionally, the manner in which they responded to these questions also indicated that when it came to developing creativity, through the formative assessment techniques, the pupils were applying or initiating the strategies themselves. However, this does not mean that the teacher was enabling the child to be agentive in their learning, just that the teacher reflectively described the child as applying or initiating the formative assessment technique.

As I previously stated, in section 10.2.1.2, the nature of the questions in the survey only invited the teachers' to describe the range of assessment strategies they employed and not *how* or *why* they chose to employ them. As a result there was a lack of in-depth detail to interpret whether or not how far they were, in actuality, able to elucidate creativity through these formative assessment techniques. It was hoped that the post-observational interviews would temper this issue but unfortunately due to a lack of interviewer probing I was unable to discern exactly how the teachers' could (or did) adapt their chosen techniques to truly capture evidence of creativity-in-learning. Although there was an indication, from the examination of the survey's data, that social exchanges could augment the assessment of both on-going learning and creativity. The nature of social exchanges, between teacher and pupil(s), reifying creativity-in-learning is discussed further in the following section.

10.3.4 Discerning how formative assessment strategies could (and have been used to) assess creativity-in-learning

Having managed to elucidate how teachers believed they could assess creativity through observations, talk and questioning I wanted to discern *'How might [their] on-going assessment practices be naturalistically adapted to assess creativity?'* I have acknowledged that questioning was only one component of the many interpersonal interactions which take place during one science lesson. For example, open-ended statements could also, reportedly, lead to exploratory-talk interactions. It was this type of exchange (or classroom talk), I theorised, which could reify creativity-in-learning (see section 2.2-B.1.1.2) whilst simultaneously illuminating a formative assessment practice that is (or can be) naturally integrated into the flow of the lesson, i.e. the spirit of AfL (Bird, 2011). By examining specific verbal exchanges (that demonstrated constructive critique of another's ideas or propositions) in the science classroom, I reasoned in the methodology chapter (section 5.6.2.6) and in chapter 8 (section 8.1), that I would be responding to RQ4 (*italicised* above). However, because Bird (2011) challenged the view that only exploratory talk was of educational value I decided to generate a more comprehensive theoretical framework to consider all the available verbal classroom interactions. This was originally generated and described in section 2.2-B.1.1.2 of the literature review (see table 2.1 in literature review).

I examined five excerpts from each of the three observations (A-C); these were integrated into their respective events maps (see figures 7.11a-b, 7.12a-b and 7.13a-b, section 7.7 of chapter 7) ready for further comparison and the results of this analysis can be found in chapter 8 of this thesis.

I feel it is necessary to briefly reiterate how I envisaged exploratory dialogue here, for the purposes of the following discussion. It was originally illustrated on table 2.1 and described as a shared cognitive spiral which twisted and bent back in on itself as ideas were critically and creatively articulated, amended, honed and refined between classroom participants (teacher and pupils). This, I argued, aptly resonated with Fisher's critico-creative practice and my interpretation of creativity-in-learning. However, post-analysis, this specific type of exchange was not aptly discerned through the chosen excerpts, this is despite all three teachers' adopting a variety of creative strategies (these activities are represented further on their respective events maps, see figures 7.11-7.13 in chapter 7). I concluded that whilst these creative activities generated opportunities enabling pupils to vocalise their thoughts and ideas, via a number of different communicative means (such as, through instructional talk, recitation, cumulative discussion and a truncated form of exploratory dialogue) the ZPD, as I had depicted it in chapter 7 (which required vocalised iterations of both the learner agency and teacher interventions/challenges) was not made explicit (i.e. it was not verbally explicit). Thus, I could not claim that on-going developmental learning (i.e. the spirit of AfL) was realised in cases A-C.

It was in the summary of chapter 8 that I referenced Coles (2015), when he stated that '…all we [as teachers and educators] can hope to do... is refine and work on how we make distinctions, through joint activities…[whilst] reflecting with others.' (*ibid*:237). I deliberated upon this whilst considering my findings and realised that when endeavouring to foster creativity-in-learning, and illuminate the spirit of AfL, we, as teachers and educators, need to consider how the activities employed can be best articulated across all classroom participants (i.e. through both the teacher and students). This brought to mind a study entitled 'Improving Science Together', it involved 20 primary and four secondary schools, within the Bristol area, and its aim was to develop science teaching and learning through targeted assessment and focused teaching (McMahon and Davies, 2003). By focusing in on particular aspects of assessment, such as recording only part of the investigation and not the whole process, from beginning to end, McMahon and Davies (2003) reported that teachers had become discernibly more confident when communicating with children (*ibid*:35). Thus this study had shown that by focusing the teachers' attention on specific aspects of the investigation their own ability to confidently interact with their pupils increased. It is here that I conjecture that teachers, who wish to assess creativity-in-learning, could choose to focus on the children's ability to be both critical and creative (i.e. the critico-creative aspects of scientific enquiry). It is hoped that by concentrating on this aspect both teacher and pupil would become, over time, more confident to explore scientific concepts and/or scientific inquiries through exploratory dialogue; this then eventually, naturalistically illuminating and externalising (verbally) the pupils on-going learning (i.e. the spirit of AfL).

10.4 Summarising my discussion

In this chapter I initially reviewed my methodological approach and considered how this had affected the development of my research tools and analytical framework. I reflected upon each of these methods individually and suggested how they, perhaps, constrained the nature and extent of conclusions I could make from my data. I also considered where (or how) each method could be improved. This was done to accommodate my continuing anthropological reflective journey, that is to illustrate that I have, and am continuing to evolve into more of a constructively critical social science (rather than a purely positivist scientific) researcher.

In the second section I considered the findings from the results chapter (6-9) to triangulate the interpretative outcomes and answer my four research questions. This has provided summarised insights into how teacher's perceived themselves to be promoting creativity and discerned what three related case studies were, in real classrooms, in day-to-day practice doing to develop it.

In the next chapter I will consider the contributions that this thesis makes to the existing science education body of knowledge and how it could potentially inform primary science education. I will then consider how this could influence both teachers and/or researcher practices when endeavouring to promote or assess creativity in the science classroom. Finally, I will make recommendations for future research based on my on-going reflective thoughts of this study.

Chapter 11

Conclusion

11.1 The contribution of this thesis

I began this research in 2013 when creative teaching was being challenged by the Department of Education (Gove 2013a, 2013b), others, during this period, also believed that knowledge was being pushed aside for what was seen as a *progressive* approach to teaching, which perceived children as being undirected in their learning (Christodolou, 2014). However, the notion of creative teaching in science involving the child discovering for themselves (without the counsel of the teacher) can be tempered by evidence that authoritative information can support and augment creativity (Yeo and Tan, 2010). This is especially important in an historical context when considering the discipline of science because scientific endeavour involves critical examination of current theory (cited in the literature review, section 2.2-A.4). Whilst describing how an eminent scientist, such as Isaac Newton, works and thinks may not be fairly contrasted to that of a child developing their own subjective creativity or imagining new possibilities, the critical evaluation of the child's unique propositions against what is currently known about the world around us can be experienced by both scientist and child alike.

This coming together of both the creative and critical aspects of science, to illuminate critico-creative practices (Fisher, 2001) within the primary school environment has been one of the main focuses of my study. The distinctive contributions that have arisen as a result of my own endeavours to research this phenomenon have included:

- Developing a way to examine self-reported episodes of creativity within science lessons, from the teacher's perspective. This was achieved through a devised classification system which was adapted from Oliver's (2006) ten ways to make science teaching creative. The analytical framework was also designed to examine whether the teachers reflected upon the development of creativity as being either teacher-initiated and/or child-initiated (i.e. TIC and CIC respectively), in order to consider the teacher's view of creativity in both teaching *and* learning.
- Devising a framework to graphically illustrate when individual characteristics of creativity were evident in observed science lessons. Three related cases (A-C) were reflexively chosen to demonstrate how this research tool rendered more explicit the ways that different forms of creativity could be reified. Each case respectively exemplified three differing teaching approaches, i.e. expositional, 'teaching creatively' (TC) and 'teaching

for creativity' (T4C). Each of these three kinds of teaching approaches have never been visually depicted in such a way before.

- Producing time-lined representations of science lessons (as events maps) to demonstrate the activities, teacher/pupil inter-actions, in sequential order. This drew attention to whom (teacher/child) initiated creative acts and/or how creativity within an activity emerged. The research tool was designed to be cross-referenced with the observational graphical representations, through a question frequency timeline (i.e. a representation of the number of open, pseudo-open or closed questions asked per minute).
- This representational timeline events map offers a record of a lesson that reifies much more clearly when and how creativity was realised. It, perhaps, even more importantly, offers a reflective testimony to consider (for teachers and researchers) when and where creativity could be extended or further developed in future science learning.
- In categorising types of creativity it became clear that existing classifications are limited and that a more comprehensive review to articulate the differences between TC, TIC, T4C, CCA, CIC is required.
- Finally, I have addressed the relationship between the affordances provided in the science lesson (as depicted through the events map) and the verbal interactions taking place during the science lesson. Achieved by cross-referencing five verbal exchanges (also tied into the events map) and inspecting these for reifications of creativity. This examination was also designed to illuminate a formative assessment practice that is (or can be) naturally integrated into the flow of the lesson, this is known as the spirit of AfL (Bird, 2011). The excerpts were examined through a newly formed, comprehensive analytical framework, which was conceptualised with all three of Mercer's (2008) types of talk (disputational, cumulative and exploratory) in mind, these were combined with Alexander's (2008) lesser-known five patterns of teacher talk (rote, recitation, instruction, discussion and dialogue). Each excerpt was also depicted illustratively post-analysis, these could be cross-referenced with the events maps through photographs which tied in with the specific activities taking place.

11.2 Conclusions drawn from the study

The main body of this thesis emerged through three different methods. First I invited teachers to articulate their views, through a survey, of how they fostered creativity in their science lessons through their practices and via formative assessment. Following this I observed three related cases (A-C) to illuminate where and how creativity was evident. Finally, I interviewed the teachers from cases A-C post-observation. A direct extrapolation and cross-case analysis could not take place between the survey and observations because the three teachers observed did not complete the survey, despite various promptings, hence why it seemed a prudent measure to triangulate the interview questions with those from the survey.

The interview and survey data was analysed using frameworks developed from Ann Oliver's (2006) ten ways to make science teaching creative, and Dylan Wiliam's (2011) five key formative assessment strategies. Interview data was also examined inductively to explore how far self-reports of creativity reflected observed practices. The interpretive findings from both the deductive and inductive analysis can be found in chapter 6 (the survey) and chapter 9 (interviews).

Observations were then examined through four different interpretive means (as briefly described in section 10.2.2 of the previous chapter). These methods of analysis enabled the generation of three different graphical representations, each depicting when characteristics of creative practice were evident, as interpretive through a single science lesson. See chapters 7 and 8 for these interpretive illustrations.

The results from the examination of the survey and interview data sets (see chapters 6 and 9) indicated that the teacher's perceived themselves as supporting creativity by capitalising on naturally occurring everyday phenomena, whilst providing opportunities to build a relationship with the scientific through the use of demonstrations and analogies. These activities provided the children with opportunities to discern the world from another vantage point, perhaps by observing the previously unseen world through another means. The episodes of creativity described also (in many cases) suggested that the learners examined and explored scientific concepts independently of the teacher (although whether this was achieved as individuals or collectively is not really clarified through the reported activities). However, there was an additional finding elucidated through the inductive grounded approach, when examining the interview data, that is, creativity in science was also reportedly supported by teachers when they challenged the children's alternative ideas and suggestions. It was fascinating to discover that all these findings were in-line with other researchers conclusions when they observed classroom practice (Na and Song, 2013; Niebert *et al*, 2012; Sikoyo and Jacklin, 2009), although these researchers did not associate their observable findings with the promotion of creativity.

My own observations of three related cases (A-C) helped me to compare what the teachers perceived themselves as doing. This was achieved by contrasting the nature of creativity in the science classroom (articulated through post-observational interviews) to that which they were observed (by a researcher) to enact, as illustrated through their differing understandings and interpretations of creativity in practice (see chapters 7, 8 and 9). This comparison took place because a previous study, by Johnston (2007), uncovered there was little relationship between ten pre-service teachers' espoused views and what, in reality appeared to occur during their science lessons. According to my inductive findings from case A's post-observational interview, the teacher believed she promoted creativity by encouraging independent learning, through the employment of open-ended strategies, and by challenging any articulated alternative considerations. However, during the observed science lesson this teacher was more likely to be found constraining opportunities for the children to develop their agency-in-learning and fire-up their imagination. Additionally, she did not discernibly challenge pupils' ideas, instead she sought to engage learners in thinking about science through her *own* creative performance. This finding adding validity to Johnston's (2007) study. Conversely to this I found it fascinating when I discovered that there was no mis-match between the teachers espoused views in cases B and C and the events taking place in their observed lessons. That is, they both articulated that they encouraged autonomy through open-ended investigations which subsequently enabled the children to be independent. However, careful analysis of cases A and B has brought into focus the ways that creative materials were used, unusual learning experiences were evident (through stories and drama) but questioning, mediation and the nature of tasks presented each constrained imaginative and creative possibilities. These findings indicate that Johnston's (2007) conclusion may not be accurate for all teachers and this alongside other research such as, Na and Song (2013), Niebert *et al* (2012), Sikoyo and Jacklin (2009), points towards the possibility that both penned and articulated self-reports of creativity in the classroom could be (or can be) accurate. There does, however, appear to be some building evidence of inconsistency between some teachers' self-reported views of their practice and the ways that external observers perceive their creative pedagogy.

As I explained at the beginning of this section, the observations themselves were initially examined through a framework which was used to graphically illustrate when individual characteristics of creative practice were evident during science lessons (see chapter 7). Whilst the framework itself could be employed to represent useful features of the teacher's practices that were evident in expositional teaching, TC and T4C (minute-by-minute), the lenses which I examined the observational data proved reflexively pertinent (they were, encouraging autonomy, risk-taking and social interactions). That is, in chapter 7, it became possible to construe that the verbal utterances could potentially illustrate the children's zone of proximal development (ZPD), but this, I conjectured, required both the agency of the child to be articulated (which could be encouraged by the teacher) and the teacher to challenge the pupils' expressed thinking (take-risks). Thus the examination of verbal exchanges, within each case (documented in chapter 8) afforded me the opportunity to illuminate a formative assessment practice that is (or can be) naturally integrated into the flow of the lesson, Bird (2011) referred to this as the spirit of AfL.

15 verbal exchanges (five from each observed lesson) were examined in total and interpreted through a newly conceptualised framework (as outlined in section 11.1 above). Post-analysis I interpreted exploratory dialogue as being demonstrated through two excerpts. This type of interaction occurred when the verbal exchanges were reaching for an idea (and/or product) through mutual critical and constructive negotiation (see section 2.2-B.1.1.2 in the literature review). A description which is akin to Fisher's (2001) critico-creative thinking (i.e. creativity-in-learning). However, these interactions appeared to be truncated because the teacher's evaluative questioning, which reflected upon the children's original articulated thoughts, either funneled the learners towards vocalising a specific or brief response instead of expressing reasoning or justifications. Additionally, from this examination of the excerpts it became discernible that the vocalisation of children's thinking to observe the ZPD (or the child's developing learning, i.e. the spirit of AfL) required both the interpersonal expression of agentive learning and the interjection of the teacher's risk-taking behaviour (their challenging of ideas) to enable the children to express *rounds* of in-depth thoughts or explanations.

11.3 Recommendations for science teachers

Having come to the end of my thesis and formulated my conclusions above (section 11.2), I turn my attention back to the beginnings of my research. I do this to reflect upon the way my findings could help practitioners develop/promote creativity in their science classroom. At the start of this doctoral journey I sought to understand the development and expression of children's creativity-in-science through teacher practices, and I have found an apt quote from Lipman (2003) which describes why I chose to do this: '…people [or teachers] who think caringly about the creative thinking of their students….seek to elicit the best possible thinking from one's charges' (*ibid*:252). Here Lipman is stating that the teacher who wants to develop creativity should try to identify and enable the children to express their *best* thinking. The pupils' *best* thinking in science, according to this thesis, being something akin to critico-creative reasoning (Fisher, 2001). It was Davies's (2011:14) description of creative teaching that suggested that the children's creativity could be articulated (or not) through the way in which teachers' were creative. Thus teachers could and should consider how their practices are already imaginative (as was the case for all three teachers observed in this study, see chapter 7), but further in turn consider how this can (or does) facilitate the children's own imaginings and innovation. This could be achieved, by the teachers, through reflecting upon the differences between TC and T4C (through a review of the events maps of their lessons) and considering where their current practices fall within these inter-dependent approaches. However, I have previously recognised that there is limited source material about the provision of developing creativity through creative teaching, thus what is required is the development of professional literature which provides greater clarity about these composite parts of teaching. Through this research study I believe that my newly conceptualised analytical frameworks can be employed by teachers to self-reflect upon their own practices and to consider how their perceived/observed teachings equate or contrast with recognised approaches to develop a learner's creativity. These fresh classification systems could also contribute to existing academic literature regarding the promotion of, and subsequent development of, creativity in primary science lessons.

To enable the children to express their creativity-in-learning (i.e. their critico-creative practices) the teacher would also need to be aware of what creativity is, especially in science. For as I stated in the literature review (section 2.2-A.1) a lack of a clear definition may lead to a variety of interpretations and this could be one reason why teachers are not clear about 'what' it is or the 'best way' to support its development (Kamphylis *et al*, 2009). Whilst I, for the purposes of this thesis, had originally defined creativity as *the formation of all possibilities and fresh concepts that are original and useful to their creator,* this definition didn't really capture the nuanced nature of its expression. I have gone on to suggest that the articulation of creativity involved reciprocal iterations of both critical and creative exchanges between classroom participants, and this type of interaction has been described as exploratory, as outlined in section 11.2 above. However, this is only one form of verbal interaction amongst others, that has been found (or observed) within the classroom (see section 2.2-B.1.1.2), thus I have offered another theoretical framework (table 2.1) as a means for teachers to reflect upon the verbal exchanges which occur during their science lessons. It is hoped that this fresh perspective on classroom interactions will enable the teachers to become more aware of how they interact with their pupils and how to elicit their pupils' *best* thinking.

It may also be that those responsible for pre-service teacher education and professional development of qualified science teachers could adopt and consider the ways I have reviewed practices and draw on them for pedagogic developmental purposes (i.e. through continued professional development).

11.4 Recommendations for future research

Throughout this thesis I have directly, and at times indirectly, highlighted where further research is (or may be) needed. These areas of further research include/involve:

- Examining, through additional research studies, the extent to which the current listed bilateral categories, in my reconceptualised version of Ann Oliver's ten ways to make science teaching creative, inform both creative teaching and learning (see the discussion chapter, section 10.2.1.1). This needs to be done whilst simultaneously considering other aspects that may have been omitted from the list, such as the teacher's risk-taking practices.
- Future surveys could be distributed, and interviews carried out, to invite teachers to answer questions that prompt them to describe when and how, in their experience, specific formative assessment techniques have provided '…evidence [of learning, and then to explain how this has been]… actually used to adapt the teaching to meet the needs [of the learner]' (Black and Wiliam, 1999:2). This will illuminate how the teacher used the strategy, not just to elicit evidence of learning, but to also fulfil a formative purpose. Following this it would be fascinating to ask how they believe this could be adapted to demonstrate the children's emerging creativity.
- In the methodology chapter (section 5.5) I referred to research by Johnston (2007) that indicated there was little correlation between pre-service teachers' espoused views of their practices and what was, in actuality, happening. In the introduction of chapter 7 I suggested that this could potentially be true of longer serving practitioners. My interpretive findings indicated that Johnston's conclusion may not be accurate for all teachers. However, there was evidence of an inconsistency between some teachers' self-reported views of their practice and the ways that external observers would perceive their creative pedagogy. This requires further consideration.
- Exemplars of critico-creative episodes should be sought (and videoed). This could enable teachers' to reflectively consider how they could develop creativity-in-learning.
- Further observations, and reflections surrounding current literature, could go on to classify the types of creativity observable in the science classroom, with the intention to exemplify the differences between TC, TIC, T4C, CCA and CIC.
- Having reviewed the descriptors for the teacher's actions on the observational framework to more aptly resonate with Davies' (2011) description of creative teaching (see table 10.3 in chapter 10, section 10.2.2) a more comprehensive nomenclature for creativity could be developed and existing video's re-analysed to explore whether past interpretations hold true.

- Further observational data could be collected that takes into account how children (or collective groups of children) are working together and creatively contributing to the task at hand. This data could be analysed through the proposed model of the types of verbal interactions that are available in the classroom (i.e. table 2.1 in the literature review, section 2.2-B.1.1.2). The analysis of peer group (verbal) interactions (audio and/or video) could gain further insights into how children, and their peer groups, support each other, and enhance the learning experience, when thinking creatively and critically together.
- Additionally, having examined the verbal exchanges taking place between the teacher and their pupils' further research could lead to the development of an innovative analytical framework which scrutinises the actional movements of the participants. This, it is hoped, could illuminate the creative process through physical actions.
- Penultimately, there is also scope to examine and consider how the products (i.e. texts produced, roles-plays, poems, drawings etc...) of the science lesson could elucidate the development of creativity-in-learning.
- Finally, I described, in chapter 10, a study entitled 'Improving Science Together', it focused on the assessment of specific aspects of science (such as recording the methods) rather than the whole investigation. The findings reported that by only assessing one aspect the teachers became observably more confident when interacting with the children (McMahon and Davies, 2003). It would be fascinating to perform a similar study which focused the teachers' attention on assessing the children's ability to be both critical and creative. Through this study it would be interesting to discover whether concentrating on this aspect would enable participants to explore the scientific more confidently, over time, through exploratory dialogue.

Since Guilford's address at the American Psychological Association in 1950, where the potential to nurture creativity in the classroom was originally acknowledged, there have been a number of policy imperatives that have attempted to influence the ways in which UK schools and teachers promote and foster creativity. Some have considered this phenomenon as a concept that can place the child at the centre of their own education (CACE, 1967a; 1967b), whilst others have recommended that a particular teaching approach is required to promote and nurture it (NACCCE, 1999). Creativity has also been acknowledged by many as being important enough to be accepted (and welcomed) when observed in the classroom (Ofsted, 2003; QCA, 2004; Ofsted 2010; Ofsted, 2013). However, these endorsements of being creative in the classroom have been arguably tempered by policy imperatives that have focused on attainment levels in Mathematics and English (DES, 1987; Ofsted, 2003) and this has not been helped by the challenges laid against creative teaching in more recent years (Gove 2013a; 2013b). Despite this there are still research groups who aspire to study and subsequently help develop (and assess) creativity in the classroom (Lucas *et al,* 2013). Lucas *et al's* research is taking place in partnership with the Organisation for Economic and Co-Operative Development (OECD). This organisation aims to 'promote policies that will improve the economic and social well-being of people around the world' (OECD, 2017) and they state that governments play a key role in promoting these (OECD, 2015). Thus by endorsing Lucas *et al's* research, they are inviting world governments to recognise creativity as an essential skill for global prosperity.

Whilst the debate of how best to promote (recognise and celebrate) creativity in the classroom has been on-going for over 50 years I have concluded, in this thesis, that creativity-in-learning can (and should) be supported through teaching practices that promote its naturalistic expression. This begins with teachers who are not only creative in the way they choose to employ/initiate their activities but also in the way they seek to elicit thinking from their pupils (Lipman, 2003) as well as invite their justifications for their imaginings and innovation.

Ultimately this thesis makes a contribution to the continuing arguments that surround the nature of creativity, and the ways in which it can be developed in the primary school classroom. I have suggested how it can be better recognised, promoted, assessed and celebrated in science by teachers and their pupils.

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APPENDIX

APPENDIX 5.A: A summary of research stages, including the focus during each stage of the research and the methods employed to answer four research questions.

Research questions are:

1) How do teachers describe and promote creativity in the primary science classroom?
2) What appear (from researcher observations) to be key features or characteristics of teaching to support creativity?
3) Can teachers' descriptions of formative assessment-in-practice elucidate how they (could or already do) provide opportunities to assess creativity-in-learning?
4) How might on-going assessment practices be naturalistically adapted to assess creativity?

Stages in research process	Focus during stage (referencing RQ's, see above)	Methods employed during research stage

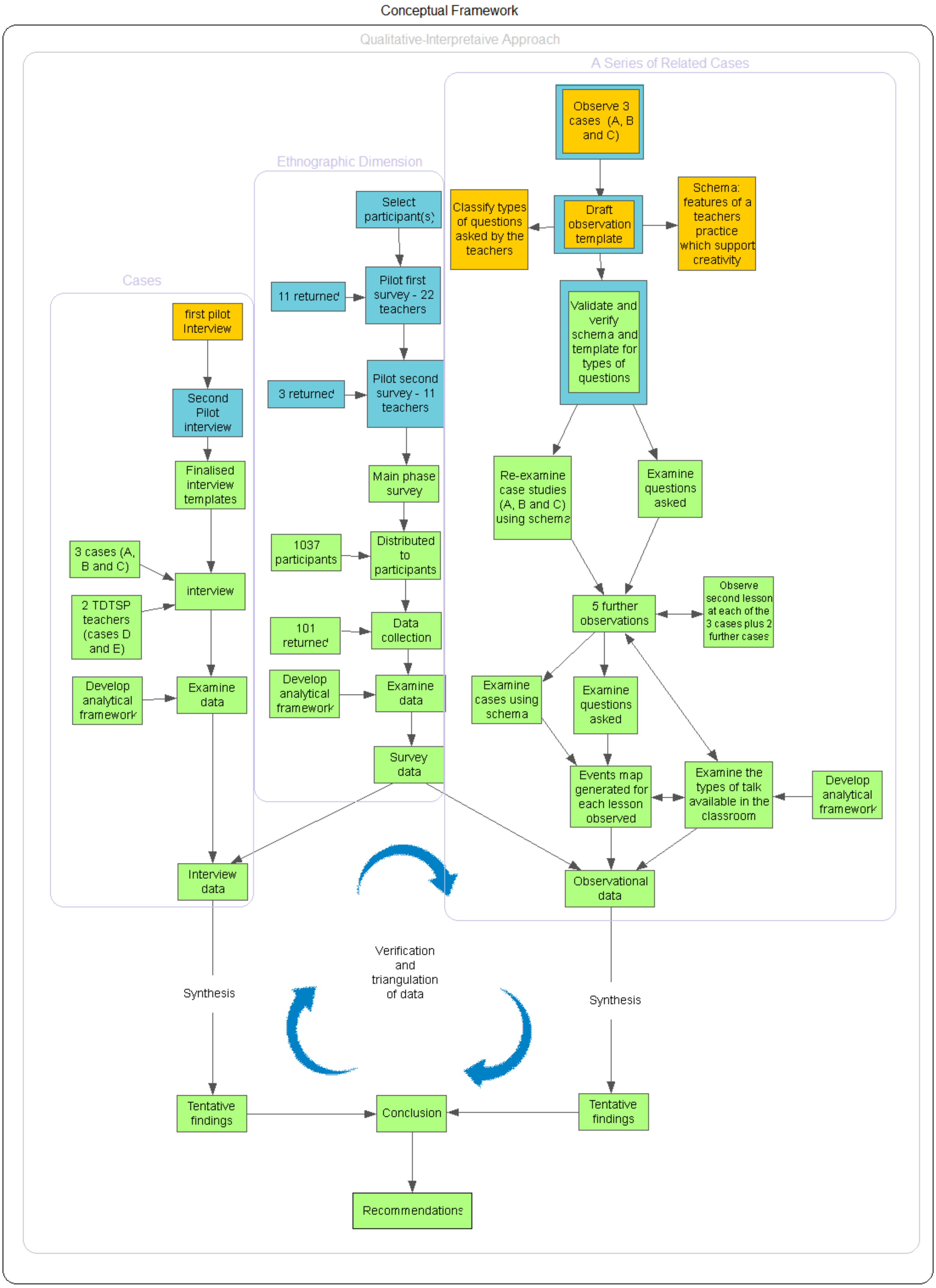
Stage 1:
 	
Shaded yellow on figure 5.8 in appendix 5.B
	• What does creativity look like in primary school science?
	• What are the key characteristics within teaching approaches which augment/support creativity in primary science? (RQ2)
	• Develop an analytical tool which provides a systematic interpretation of the characteristics of science teachers' creative practice. (RQ2)
	• How are formative assessment strategies being applied in creative primary science classrooms? (RQ3)
		• Literature review centering on creativity (and its formative assessment) within education, with a focus on its application, development, generation and its place in primary and science education.
		• Observe three cases (A-C) to review teacher's creative practices.
		    ○ Analysis and examination of 3 cases to consider to 2 aspects:
		        ▪ The questions asked by the teacher and
		        ▪ The way in which teachers provide opportunities to nurture creativity.
		• Pilot interview one PSTT recognised teacher (appendix 5.L).

Stage 2:
 	
Shaded blue on figure 5.8 in appendix 5.B
	• Illuminating characteristics of the different teachers' creative practice (i.e. TC and T4C) be generalised? (RQ2)
	• Develop and pilot questionnaire and interview questions to find out:
	  ○ What are teacher's perceptions of creativity in the primary science classroom? (RQ1)
	  ○ What do teachers do to promote creativity? (RQ1)
	  ○ How is creative thinking currently being formatively assessed? (RQ3)
	  ○ What are the characteristics of successful formative assessment within the classroom? (RQ3 and 4)
	• Consider how talk in a science lesson can augment creativity and how does this relate to formative assessment? (RQ4)
		• Extend literature review, focusing on the nature of creative teaching, the application of formative assessment in the science classroom and how policy imperatives have informed practice.
		• Continued scrutiny of the three feasibility case studies to develop analytical tools.
		• Pilot survey (appendix 5.D): 20 teachers from the TDTSP (second cohort) invited to participate. 11 returned completed.
		• Piloting re-conceptualised survey (appendix 5.F): 11 teachers' from the TDTSP (first cohort) invited to participate, three returned completed.
		• Interview (appendix 5.M) one Oxford Brookes University primary science lecturer.

Stage 3:
 	
Shaded green on figure 5.8 in appendix 5.B
	• How do I illustrate/exemplify what the teacher made present (or made visible) to the learner to provide increasing opportunities to develop creative thinking? (RQ2)
	• Design an analytical framework (for survey and interview responses) which divulges the teacher's perceptions of how they report to foster creativity in the primary science classroom (RQ1).
	• Can teachers' perceptions of assessment-in-practice enable them to assess creativity-in-learning? (RQ3)
	• Validate, verify (and modify) an analytical tool which examines the talk available in the science lesson and relate to the letter of AfL and the spirit of AfL (RQ4).
		• Extending literature review, focusing on the nature of the learner's creative thinking.
		• Continued scrutiny of cases to develop framework that examines the types of talk available in the classroom.
		• Revisiting and observe the same 3 cases (ref: stage 1) plus 2 further cases (D and E).
		  ○ Analyse all observations through developed creative schema.
		• Events maps created for 6 observations (cases A, B and C, both lessons).
		• Examine Interviews (11 questions):
		  ○ Cases A-C.
		  ○ Two from the TDTSP (cases D and E).

		• Surveys distributed (appendix 5.C): ○ Teachers invited to participate (PSTT college fellows and schools involved in the PSQM scheme). 101 returned completed. • Responses from survey's and interviews examined through a framework informed by Ann Oliver 10 ways to make science creative and Wiliam's five key strategies of formative assessment. • Responses from interviews also examined inductively to enable triangulation of data.

APPENDIX 5.B: Research Design Summary



(Figure 5.8)

APPENDIX 5.C: Main Phase Survey

School of Education
Email: education@brookes.ac.uk
www.education.brookes.ac.uk/

'Creativity in Primary School Science Teaching'

Teaching Practices in Primary Science lessons.

This questionnaire seeks to explore how you, as a teacher, support creativity and assess children's achievement in generating novel and creative ideas in their learning.

There are three parts to this questionnaire (Sections A, B and C) and the complete questionnaire consists of 17 questions and should take 10-15 minutes to complete.

Thank you.

Section A: (Personal Details)

Name of Teacher: ______________________________

Name of School: ______________________________

Year Taught: ______________________________

Length of time teaching: ______________________________

Year groups previously taught: ______________________________

Section B: (Science Lessons)

1. How often do you support the children to develop curiosity in science?

Frequently ☐

Sometimes ☐

Never ☐

2. How often do you support the children to ask questions in science?

Frequently ☐

Sometimes ☐

Never ☐

3. How often do you support the children coming up with ideas in science?

Frequently ☐

Sometimes ☐

Never ☐

4. How often do you support the children to reflect on ideas in science?

Frequently ☐

Sometimes ☐

Never ☐

5. How often do you encourage the children to think independently in science?

Frequently ☐

Sometimes ☐

Never ☐

6. How often do you support the children to overcome challenges in science?

Frequently ☐

Sometimes ☐

Never ☐

7. How often do the children create something new (poem, song, enactment, individual experiment etc) in science

Frequently ☐

Sometimes ☐

Never ☐

8. **Please describe the most creative science activity you have taught.**

9. **Please describe the most creative thing your children (or child) has done in a science lesson**

10. **Please describe the most creative thing you think your children (or a child) have/has done in any lesson, not science!**

11. Which aspects of your creative lessons has sparked the children's interest in science?

12. What things make being creative in the science classroom difficult?

13. Why do you think children might find it difficult to be creative in a science lesson?

Section C: Your Assessment Strategies

14. Which aspects of students' thinking are not measured via summative science assessment tests?

15. Can you describe the range of different strategies you use currently to assess your children's on-going progress in science learning (i.e. tests, tasks or assessment strategies)?

16. Which of the assessment strategies described in Q15 most closely assess creative ability in science?

17. **Why does the assessment strategy discussed in Q16, in your opinion, more readily assess creative ability?**

Would you be willing to be involved in a follow up interview? Yes No

Would you be willing to be involved in a follow up observation? Yes No

Your indications here are taken to indicate whether or not you wish to be further involved in this project (unless you subsequently inform me otherwise).

Thank you for completing the questionnaire.

APPENDIX 5.D: First Pilot Survey

OXFORD BROOKES UNIVERSITY

School of Education
Email: education@brookes.ac.uk
www.education.brookes.ac.uk/

PILOT: QUESTIONNAIRE

'Assessment of Creativity in Primary School Science Teaching'

Teaching Practices in Primary Science lessons.

This questionnaire seeks to explore how you, as a teacher, support creativity and assess children's achievement in generating novel and creative ideas in their learning.

There are three parts to this questionnaire (Sections A, B and C) and the complete questionnaire consists of ten questions. Please place the relevant frequency letters in the appropriate boxes (i.e. F-Frequently; S-Sometimes or N-Never) or write in the spaces provided.

Thank you.

Section A: (Personal Details)

Name of Teacher: ______________________________

Name of School: ______________________________

Year Taught: ______________________________

Length of time teaching: ______________________________

Year groups previously taught: ______________________________

Section B: (Science Lessons)

1) How often do you use any of the creative teaching techniques/strategies listed below in science?

	Frequency key: Frequently (F) Sometimes (S) Never (N)	Optional comments: to explain or describe when/how you do this
Observations: Considering objects that pique interest, handling and observing them, looking at objects differently (i.e. using all the senses) to gather information: to construct and internalise understanding.		
Linking everyday life and personal experiences (i.e. the natural environment) with an aspect of science.		
Utilising strategies that motivate reluctant speakers (i.e. puppets): to promote engagement and motivation in all children.		
Aesthetic experiences: engaging children imaginatively by making the ordinary fascinating and/or creating a sense of wonder e.g. wow experiments, exploring science through fiction, pictorial crafts, creative writing, utilising popular media or musical representation.		
Imaginative or pretend play directed by the teacher: Children expressing science concepts via gestures and actions. (e.g. freeze frame and/or modelling).		
Experimentation (utilising practical skills): Allowing children the autonomy to share, plan, test and then evaluate ideas to formulate an explanation from evidence that connects to scientific argumentation and explanation.		
Interpreting and debating alternative perspectives by drawing on a range of ideas or challenging thinking/ideas (may not fit the child's accepted thoughts): Concept cartoons, forum theatre and brainstorming.		
Whole class dialogue: Encouraging whole group discussion to provide explanations by sharing thinking verbally and to reflect/evaluate (modify/clarify) and comment on explanations.		

Encouraging problem-finding and solving by generating and evaluating ideas and/or constructing an original or unique shared outcome (performed by constructing their own representations: e.g. a joint experiment, poster, presentation, etc).		
Questioning (teacher-led): inviting/exploring children's own individual or personal meanings/ideas (not factual recall) to promote speculation and the generation of possibilities or unique suggestions/answers.		
Children are encouraged to raise/construct their own questions (individually or as a community), they may then be encouraged to look for patterns and make connections and subsequently begin to offer explanations.		
Open-ended collaborations: imaginative or pretend play which involves trying out forms of behaviour (e.g. role play: - Thinking hats, thought tracking, taking on roles in groups).		
Other: Please specify.		
Other: Please specify.		

2) Please describe the most creative science activity (or lesson) you think you taught.

3) Please describe the most creative thing you think your children (or a child) has done in your science lesson.

4) Please describe the most creative thing you think your children (or a child) has done in any lesson, not science!

5) Which aspects, within your creative science lessons, do you think, have most motivated your pupils?

Section C: Your Assessment Strategies

1) What aspects of student's thinking are not-measured via summative science assessment tests (SATs)?

2) What science capabilities (of your children) do you think the science SATs assessed?

3) Can you describe the range of different strategies you use currently to assess your children's on-going progress in science learning (i.e. tests, tasks or assessment strategies)?

4) Which of these assessment strategies, in your opinion, most closely assesses creative ability in science? And why?

5) Please describe the characteristics of your on-going assessment that most successfully judges creativity of your pupils?

Would you be willing to be involved in a follow up interview? Yes ☐ No ☐

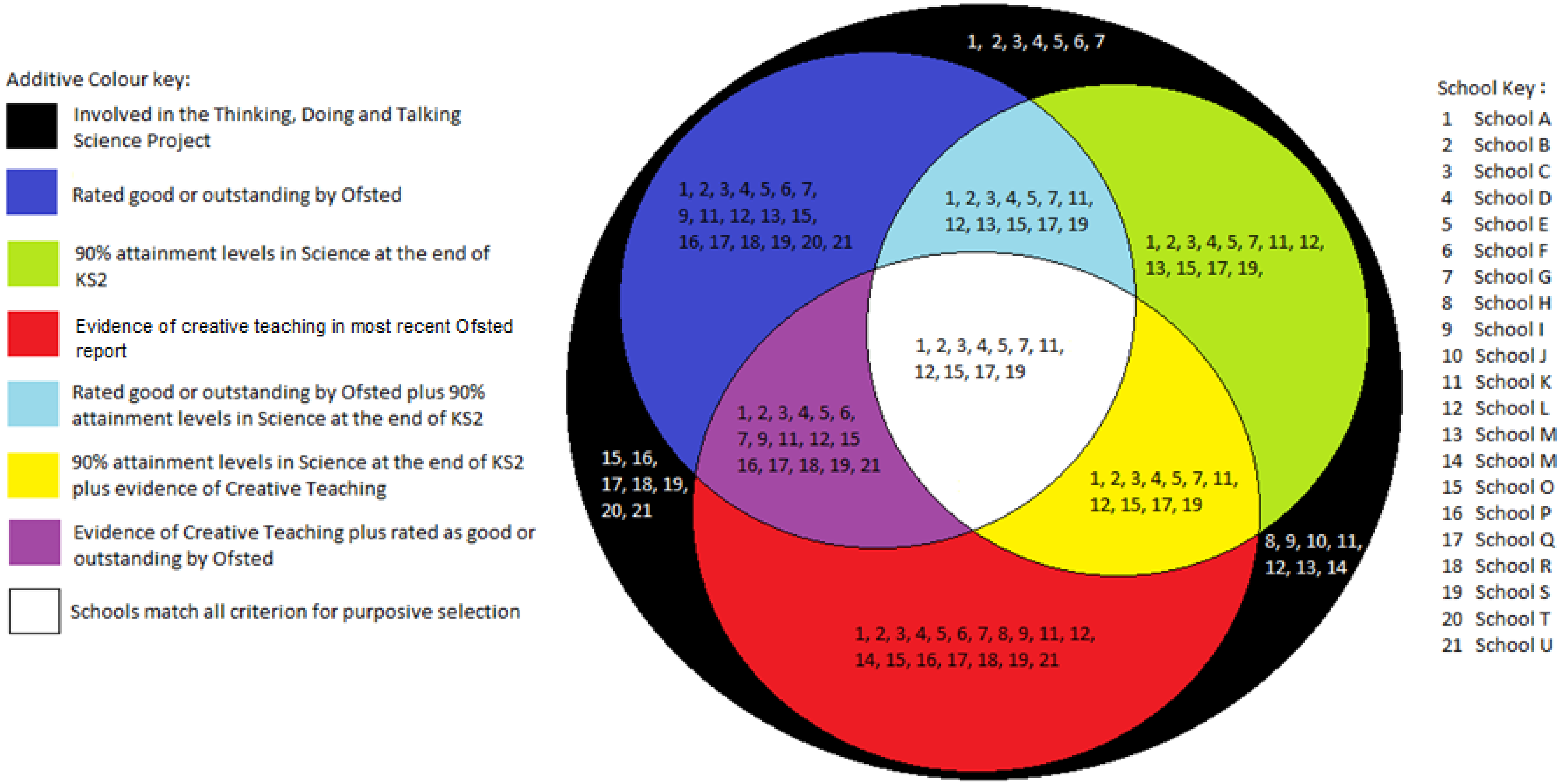
Would you be willing to be involved in a follow up observation? Yes ☐ No ☐

Your indications here are taken to indicate whether or not you wish to be further involved in this project (unless you subsequently inform me otherwise).

Signed ………………………………………… Date ……………………………………

Thank you for completing the questionnaire.

APPENDIX 5.E: TDTSP survey participants



APPENDIX 5.F: Second Pilot Survey

OXFORD BROOKES UNIVERSITY

School of Education
Email: education@brookes.ac.uk
www.education.brookes.ac.uk/

'Assessment of Creativity in Primary School Science Teaching'
Teaching Practices in Primary Science lessons.

This questionnaire seeks to explore how you, as a teacher, support creativity and assess children's achievement in generating novel and creative ideas in their learning.

There are three parts to this questionnaire (Sections A, B and C) and the complete questionnaire consists of ten questions. Please place the relevant frequency letters in the appropriate boxes (i.e. F-Frequently; S-Sometimes or N-Never) or write in the spaces provided.

Thank you.

Section A: (Personal Details)

Name of Teacher:

Name of School:

Year Taught:

Length of time teaching:

Year groups previously taught:

Section B: (Science Lessons)

1) Can you think about and list the different ways (activities and strategies) that you, as a teacher, have used in a creative science lesson that enable the children to do the following:

Could you also indicate how often you use these approaches: Frequently (F), Sometimes (S) or Never (N)

Show curiosity	Ask questions	Generate ideas	Reflect on ideas	Think independe ntly	Overcome challenges	Illustrate something creatively	Create something new

2) Please describe the most creative science activity (or lesson) you have taught.

3) Please describe the most creative thing you think your children (or a child) have/has done in your science lesson.

4) Please describe the most creative thing you think your children (or a child) have/has done in any lesson, not science!

5) Which aspects (or what it is), within your creative science lessons, do you think, have most motivated your pupils to be creative? or motivated?

6) Why, in your experience, do you think it might be difficult to be creative in the way you teach science?

7) Why do you think children might find it difficult to be creative in a science lesson?

Section C: Your Assessment Strategies

8) What aspects of student's thinking are not-measured via summative science assessment tests (SATs)?

9) Can you describe the range of different strategies you use currently to assess your children's on-going progress in science learning (i.e. tests, tasks or assessment strategies)?

10) Which of these assessment strategies, in your opinion, most closely assesses creative ability in science?

11) Why does the assessment strategy discussed in question 8, in your opinion, more readily assess creative ability?

Would you be willing to be involved in a follow up interview? Yes ☐ No ☐

Would you be willing to be involved in a follow up observation? Yes ☐ No ☐

Your indications here are taken to indicate whether or not you wish to be further involved in this project (unless you subsequently inform me otherwise).

Signed … ………………………… Date ……………………………………

Thank you for completing the questionnaire.

APPENDIX 5.G: Template: Classifying Questions

Brown and Edmondson (1984:99) definition of a question was:

'Any statement intended to evoke a verbal response'.

Question classification template

<table>
<tr><td colspan="2">Question</td><td colspan="5">Sequence Type:</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="2">Whole group</td><td colspan="2">Small group</td><td colspan="2">Individual</td><td rowspan="10">Additional notes:</td></tr>
<tr><td colspan="6">Content:</td></tr>
<tr><td colspan="2">Conceptual</td><td>Empirical</td><td>Value</td><td colspan="2">Rhetorical</td></tr>
<tr><td colspan="6">Categories:</td></tr>
<tr><td colspan="2">Managerial</td><td>Recall</td><td>Obs</td><td>Thought</td><td>Script</td></tr>
<tr><td colspan="3">Open</td><td colspan="3">Closed</td></tr>
<tr><td colspan="6">Dimensions:</td></tr>
<tr><td colspan="2">Broad</td><td colspan="2">Narrow</td><td colspan="2">Pseudo-broad</td></tr>
<tr><td colspan="3">Confused</td><td colspan="3">Clear</td></tr>
<tr><td colspan="3">Encouraging</td><td colspan="3">Authoritative</td></tr>
</table>

Key:

Content of enquiry:

Conceptual questions

Are concerned with ideas, definitions and reasoning

Empirical questions

Require answers based upon facts or upon experimental findings

Value questions

Concerned with relative worth and merit with moral and environmental issues.

Rhetorical questions

Questions to which to teacher is not expecting a response

The first three questions can often overlap and are not clear-cut.

Question Categories:

Managerial

If they were to do with running the lesson

Recall (factual)

Involves the recall of information. Recall can occur in the absence of observation

Observational (Obs)

Intimately linked with recall, requires answers based upon demonstration.

Higher order (thought)

If people had to do more than just remember facts

Script

Rhetorical questions found within a predetermined script

Open

Has more than one answer and requires the child to think

Closed

The teacher is looking for a specific answer or there is only one answer.

These can often overlap and are not clear-cut.

Question Dimensions:

Narrow/broad (sometimes decried as closed/open or convergent/divergent) and pseudo-broad dimension.

Narrow

Requires a relatively brief answer

Broad

Require a relatively wide ranging example

Pseudo-broad

The form of a broad question is used, yet the teacher is searching for a narrow answer

Confused/clear dimension

Clear

Usually clear, direct and firmly anchored in the context of the lesson.

Confusions

When the context is not obvious

Encouraging/threatening dimension

Encouraging

The same question may be asked in a variety of ways, which encourage pupil's responses.

Authoritative

Questions could confront, constrain and/or inhibit the children.

Both of the above dimensions will also depend on the tone of voice.

All criteria found within the key above were taken from Wragg and Brown (2001) except script and rhetorical which were added after further analysis of classroom observations.

I have also examined the questions using the Brown and Edmondson (1984) system of classifying questions and have suggested adding a 0 value for rhetorical questions.

0. Rhetorical, no response expected.
1. Data recall including recall of task, procedures, knowledge, values. Naming. Observing. Classifying. Reading aloud. Providing known definitions.
2. Simple deductions based usually on data provided. Providing examples of principles given.
3. Providing reasons, causes, motives or hypotheses which do not appear to have been taught in the lesson.
4. Problem solving. Sequences of reasoning.
5. Evaluating a topic, sets of values or one's own work.

O Speculative, intuitive guesses, creative, open.
F Encouraging expression of feelings and empathy.
M Management of class, groups, individuals, including directing pupils' attention, control, checking that task is understood, seeking compliance.

(Brown and Edmondson, 1984:99)

APPENDIX 5.H: Screen shot of case B's science lesson post-analysis (concerning verbal exchanges)

	Minutes	0						1						2						3						4						5								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.																																							
	Questioning the ability to demonstrate subjective/personal understandings.																																							
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.																																							
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them																																							
	Suggests a range of new novel ideas for learners/children to contemplate.																																							
Evaluating ideas by	Teacher articulates her reflections on learners/children's potential ideas (task-led).																																							
	Asks children to reflect on ideas and performances/outcomes from learning? (task-led).																																							
	Asks children to critically and/or creatively reflect upon ideas and performance.																																							
	Minutes	10						11						12						13						14						15								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.																																							
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	Questioning to check understanding in a different context																																							
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	Asks children to critically and/or creatively reflect upon ideas and performance.																																							
	Minutes	20						21						22						23						24						25								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.																																							
	Questioning the ability to demonstrate subjective/personal understandings.																																							
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.																																							
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them																																							
	Suggests a range of new novel ideas for learners/children to contemplate.																																							
Evaluating ideas by	Teacher articulates her reflections on learners/children's potential ideas (task-led).																																							
	Asks children to reflect on ideas and performances/outcomes from learning? (task-led).																																							

APPENDIX 5.I: Screen shots of case B's science lesson post-analysis (concerning risk-taking)

	Minutes	0						1						2						3						4						5								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.														■	■	■	■	■				■	■	■		■	■	■	■	■					■	■	■		
	Questioning the ability to demonstrate subjective/personal understandings.																																							
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.																																							
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them																																							
	Suggests a range of new novel ideas for learners/children to contemplate.																																							
Evaluating ideas by	Teacher articulates her reflections on learners/children's potential ideas (task-led).															■	■			■			■	■	■			■	■	■	■					■	■	■	■	
	Asks children to reflect on ideas and performances/outcomes from learning? (task-led).																																							
	Asks children to critically and/or creatively reflect upon ideas and performance.																																							

	Minutes	10						11						12						13						14						15								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.																																							
	Questioning the ability to demonstrate subjective/personal understandings.																																							
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.																																							
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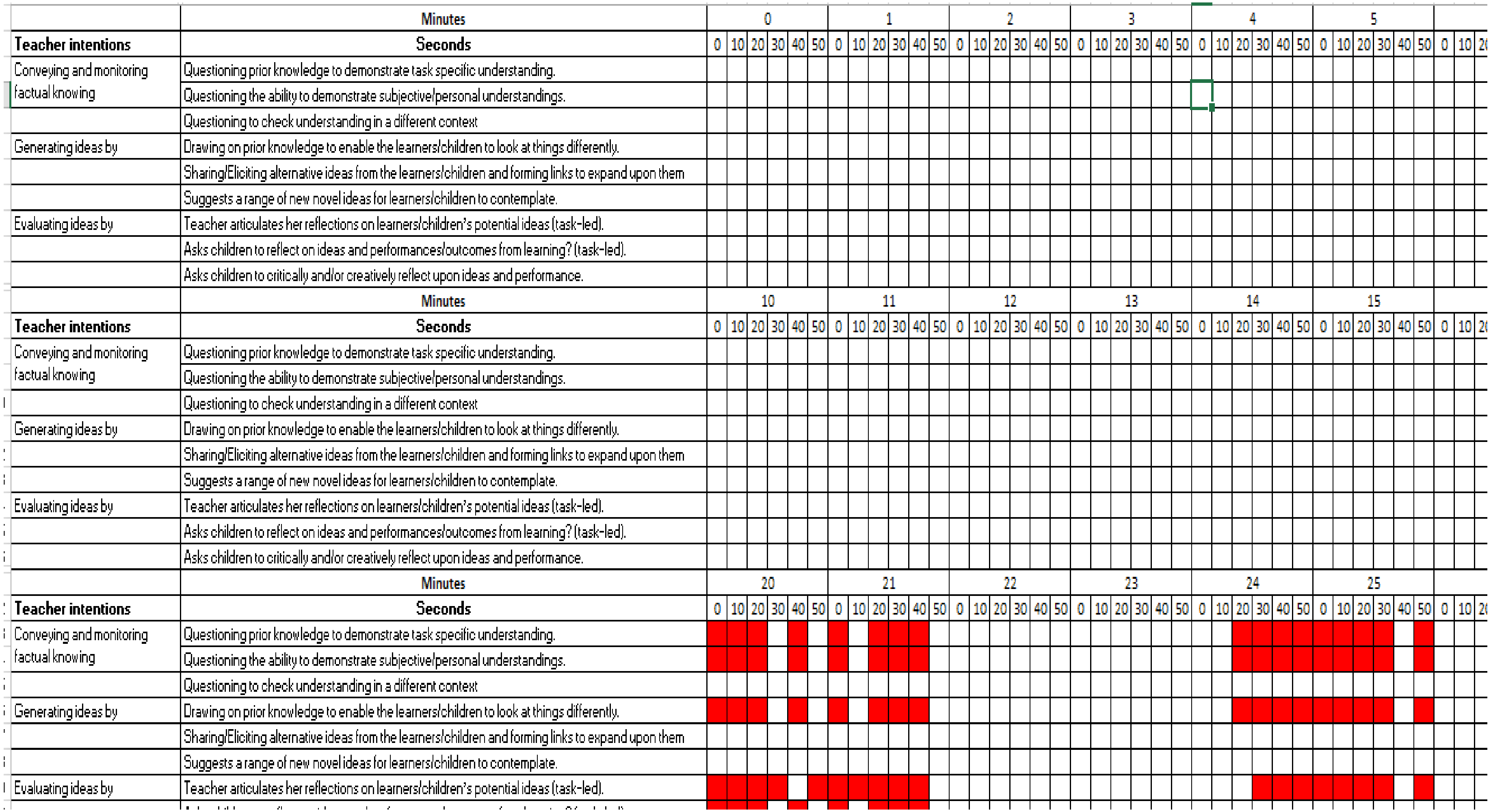
	Asks children to critically and/or creatively reflect upon ideas and performance.																																							

	Minutes	20						21						22						23						24						25								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.	■	■	■		■		■		■	■	■																■	■	■	■	■	■	■	■		■			
	Questioning the ability to demonstrate subjective/personal understandings.	■	■	■		■		■		■	■	■																■	■	■	■	■	■	■	■		■			
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.	■	■	■		■		■		■	■	■																■	■	■	■	■	■	■	■		■			
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them																																							
	Suggests a range of new novel ideas for learners/children to contemplate.																																							
Evaluating ideas by	Teacher articulates her reflections on learners/children's potential ideas (task-led).	■	■	■	■		■	■	■	■	■	■																	■	■	■	■	■	■	■		■			

APPENDIX 5.J: Screen shots of case B's science lesson post-analysis (concerning autonomy)



	Minutes	0						1						2						3						4						5								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2(
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.																																							
	Questioning the ability to demonstrate subjective/personal understandings.																																							
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.																																							
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	Asks children to critically and/or creatively reflect upon ideas and performance.																																							

	Minutes	10						11						12						13						14						15								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2(
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.																																							
	Questioning the ability to demonstrate subjective/personal understandings.																																							
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.																																							
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them																																							
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Evaluating ideas by	Teacher articulates her reflections on learners/children's potential ideas (task-led).																																							
	Asks children to reflect on ideas and performances/outcomes from learning? (task-led).																																							
	Asks children to critically and/or creatively reflect upon ideas and performance.																																							

	Minutes	20						21						22						23						24						25								
Teacher intentions	**Seconds**	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	20	30	40	50	0	10	2(
Conveying and monitoring factual knowing	Questioning prior knowledge to demonstrate task specific understanding.																																							
	Questioning the ability to demonstrate subjective/personal understandings.																																							
	Questioning to check understanding in a different context																																							
Generating ideas by	Drawing on prior knowledge to enable the learners/children to look at things differently.																																							
	Sharing/Eliciting alternative ideas from the learners/children and forming links to expand upon them																																							
	Suggests a range of new novel ideas for learners/children to contemplate.																																							
Evaluating ideas by	Teacher articulates her reflections on learners/children's potential ideas (task-led).																																							

APPENIDIX 5.K: Main Phase: Interview Schedule

Q1. How would you, as a teacher, describe creativity within i) teaching and ii) learning?
Q2. Can you provide some examples, from your experience, of i) your most creative teaching and ii) the children's at their most creative during science?
Q3. What are the benefits for the children, in your experience, of i) creative teaching and ii) creative learning?
Q4. What are the challenges for you as a teacher, when developing creativity in the confines of the science lesson?
Q5. What are the challenges for the children to be creative when in a science lesson?
Q6. Do you think it is easier to be creative in other subjects, other than science? If so how and why?
Q7. In your experience, are there some children that you believe would have more (or less) of an aptitude for creativity in science than others?
Q8. How do you ignite creativity in your science lessons?
Q9. How do you currently assess the children's progress in science?
Q10. How do you currently assess the development of creativity within your science lessons?
Q11. Are there any strategies that work better to assess creativity and why?

A table depicting how each of the 11 interview questions triangulate with the questions found in the survey (associated with relevant RQs).

Interview Question Number	Triangulates with which question from the survey (appendix 5.C)	Helps to answer RQ number (section 5.4)
1		1
2	8,9	1
3		1
4	12	
5	13	
6	10	
7		
8	11	1
9	15	3
10	16	3
11	17	3

APPENDIX 5.L: First Pilot Interview Schedule *adapted from Craft *et al's* (2014) study

<u>Craft *et al's* Interview schedule</u>

1) 'We have chosen to learn about [your school] because of its work in developing creative teaching and learning - how would you as a teacher characterise/epitomise this work?
2) Please give a brief summary of your professional career and the importance you place on creative teaching and learning policies if at all.
3) Can you give us some examples of what you see as creative teaching and learning from your practice or from school policies?
4) What benefits do you think creative teaching and learning generates (long/short term)?
5) How can assessment/creative teaching and learning issues be addressed?
6) How do you personally balance individual assessments, meeting learning targets and creative teaching and learning? Do you think this is possible in all schools?
7) Can you give us any examples of how or when you have integrated these two aspects? And why - what was the particular benefit in that situation?
8) In what ways do you think school policies help maintain creative teaching and learning practices? Do you think these can be worked for other schools?' (Craft *et al*, 2014:23)

<u>First Pilot Interview Schedule *adapted from Craft *et al's* (2014) study</u>

1) We have chosen to talk to you because you have been recognised as an outstanding primary science teacher who develops creativity within her teaching and learning – how would you, as a teacher, characterise this?
2) Can you provide some examples of what you see as creative teaching and learning?
3) What are the benefits, in your experience, of creative teaching and learning?
4) How do you balance the tensions between individual assessments, meeting learning targets and creative teaching?
5) Can you give an example of how or when you have successfully integrated these aspects?

APPENDIX 5.M: Second Pilot Interview Schedule

1) How would you, as a teacher, characterise creativity within i) teaching and ii) learning?
2) Can you give us some specific examples, in your experience, of what you see as i) creative teaching and ii) creative learning?
3) What are the benefits, in your experience, of i) creative teaching and ii) creative learning (short and long term)?
4) How do you as a teacher ensure you i) teach creatively, ii) have your children develop their creativity, and iii) how do you assess their creativity (ie: when do you know they have been creative?...and how do they know they have been creative?)
5) How do you, as a teacher, balance the tensions between teaching creatively, developing their creativity and assessing the children's creativity in the confines of learning science in the classroom environment (i.e. time constraints and learning objectives)?
6) How have you managed to assess creativity of individuals when they have produced group or shared creative outcomes?
7) What do you think are the barriers to assessing creativity in science?
8) Why do you think there appears to be generally little creativity in science teaching (and more so, learning)?

APPENDIX 6.A: The summarised interpretation of Ann Oliver's ten ways to make science teaching creative

Turning predictable outcomes into something better occurs when making the common place intriguing, by not following a prescribed route.

Making the ordinary fascinating becomes considering everyday objects and phenomena to stimulate interest.

I envisage *sharing a sense of wonder* as involving all people in the classroom (teacher and/or child) when developing and disseminating a sense of amazement at the surrounding environment and world.

Seeing differently is about more than just looking, it is about the teacher and/or child seeing opportunities to change perspectives so that fresh varying perceptions can be discerned and/or considered.

M*aximising opportune moments* involves everyday phenomena which can be employed to create (spontaneous) links to the scientific.

Humanising science (i.e. making science more human) occurs when pupils are enabled to see the scientific through human endeavour, that is by considering/participating in the characteristics of (past or present) scientists.

The definition of *valuing questions* should take into account both the teacher and/or pupils when they raise and identify (appropriate) scientific questions.

Modelling explanations, according to Oliver's, Davies's and McGregor's description of this category, can only be described as providing opportunities to develop a relationship between the scientific and what is already familiar, through everyday phenomenon and analogies.

The way I have described *encouraging autonomy* can be both teacher mediated and child-led, here the learners will be encouraged by the teacher to make decisions, whilst exploring and playing independently.

Oliver's explanation of *allowing for flexible beginnings* states that the autonomous meanderings of children are never wrong, but unlike her description of encouraging autonomy she states that the intervention of the teacher would be required.

Examples of the teachers' responses to questions 8-11 can be found below, in appendices 6.B-6.E (right-hand column of table). Each self-reported episode of creativity has been bilaterally interpreted through CCA, TIC and/or CIC sub-categories (right hand column) after being associated with one of Oliver's ten categories (left-hand column). However, as has already been described, these written descriptions can be classified into more than one of Oliver's ten ways to make science teaching creative (see section 6.2.1.2). Thus I have also included, below the teacher's response, the other categories the creative episode could also be associated with.

When the notation not applicable (N/A) is written within the teacher description column (right-hand side) this indicates that none of the self-reported episodes of creativity could be associated with the sub-categories (i.e. CCA, TIC or CIC). This use of N/A is the same for appendices 6.C, 6.D and 6.E.

APPENDIX 6.B: Teacher accounts of the most creative science activity they have taught (with Ann Oliver's ten ways to make science teaching creative in mind)

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a CCA**
Turning predictable outcomes into something better	Response 92: 'Gases-introductory input lessons re gases and their properties: Using hot air balloon theme after watching balloon festival - class created large tissue paper balloons and used hairdryers to fill them with hot air to see them rise. Then created own hot air balloon for display in DT using papier mache. Design[ed] decorations, literacy-write adventure story of travel in my hot air balloon, PE in dance use hot air balloon theme as stimulus for movement and dance/drama to represent parts of adventure'. Also seeing differently, maximising opportunities and modelling explanations.
Making the ordinary fascinating	Response 66: 'Making habitats in the woods for an imaginary creature using the resources around and considering the food source. These were then photographed'. Also Turning the predictable into something better and seeing differently.
Sharing a sense of wonder	N/A
Seeing differently	Response 13: 'Space - Pupils learned 1 fact about each planet and created an action for it, e.g. 'mercury is fastest round the sun', so they ran on the spot, 'Venus is the hottest' so they mopped their brow etc. Pupils all know order of planets from this'.

	Also seeing differently.
Maximising opportune moments	N/A
Valuing questions	Response 15 'Scene was set where a travelling circus had left a bowl of salt outside in torrential rain (bowl of salty water given to children). Questions...where had the salt gone? (dissolved) No money left to buy more (clowns furious when chips are unsalted!!) what will the ring master do?' Also turning the predictable into something better, valuing questions and modelling explanations.
Modelling explanations	Response 35: 'Early on in y4 we investigate how mammoths kept warm by building child designed mammoths with bottles of warm water and various types of brown fur. One fur type caused some discussion, because it looked just like mammoth fur ...' Also turning the predictable into something better, making the ordinary fascinating and seeing differently.
Encouraging autonomy	Response 21: 'Making a clay monster/alien and the making a show box habitat for them. Created an imaginary animal and then created its basic needs'. Also making the ordinary fascinating and seeing differently.
Allowing for flexible beginnings	Response 56: 'I[n] response to an investigation children were given the opportunity to present their findings in any way they wanted. Some came up with a new report, some a rap, a poem, a radio show etc'. Also turning the predictable into something better, making the ordinary fascinating, seeing differently and modelling explanations

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a TIC**
Turning predictable outcomes into something better	Response 100: 'Children were having trouble grasping the concept of repeat readings - they knew it wasn't to get the right answer, and they knew the value of taking an average, but they just accepted three readings was sufficient, and didn't question whether their results were reliable, or whether they needed even more readings. I devised a circus of activities which demonstrated how chn[*sic*] could use the same equipment, in the same conditions and get different results. The activities were chosen to include: - a range of measuring units and equipment - results that could easily be

	influenced by human error, human nature or random events Children had to complete each activity three times and then say if they could confidently predict the next result, or if they would need to do further testing in order to make a confident prediction. If they chose to do further testing, they had to explain why this was so and their results were not similar'. Also making the ordinary fascinating, seeing differently, maximising opportune moments and encouraging autonomy
Making the ordinary fascinating	Response 75: 'In a science lesson about reproduction in flowering plants, I used the children to create the parts of the flower - sepals, petals, anther etc. The pollen was represented by post-it notes which could transfer from the body of an insect (another child) onto the stigma'. Also turning the predictable into something better, seeing differently and modelling explanations
Sharing a sense of wonder	N/A
Seeing differently	Response 87: 'I gave my year 4 class different materials, beakers and water and gave them the challenge of designing a fair test, to see which material insulated the water the best. I often give the children equipment and ask them to discuss what the equipment is - what it can be used for etc'. Also making the ordinary fascinating, seeing differently and encouraging autonomy.
Maximising opportune moments	Response 37: 'Electricity - children were taught to make circuits but we put this into practice by making our own classroom burglar alarm and at Christmas we took the opportunity to light up our own Christmas tree (for a Christmas tree competition). We won the first prize!' these children are now in year 6 and till today they talk to me about circuits and how they still remember how they can make and put it into a practical context'. . Also turning the predictable into something better and making the ordinary fascinating.
Humanising science	Response 42: 'Asked children to explore gravity being like Isaac Newton. How can you make a toy car move without touching it? How can you make a piece of paper fall faster? Do all objects fall at the same speed?' Also turning the predictable into something better, making the ordinary fascinating, seeing differently, valuing questions, modelling explanations and encouraging autonomy.

Valuing questions	Response 46: 'I introduced magnets to the children in year 3 by allowing them to play and experiment freely with the magnets of different types and sizes and shapes. I encouraged them to come up with their own questions about magnets and their properties whilst circulating around the classroom'. Also turning the predictable into something better, making the ordinary fascinating, seeing differently, encouraging autonomy and allowing for flexible beginnings.
Modelling explanations	Response 67: 'Making a pirate ship out of foil and seeing how many coins the boat could hold until it sank. I wrote a wanted poster for a pirate ship which described the task to begin the investigation. All groups had the same amount of foil and could make their boat any shape'. Also making the ordinary fascinating and encouraging autonomy.
Encouraging autonomy	Response 28: 'As a year six teacher, I used to do a 'cross curricular' unit of work based around the Interdependence and Adaptation Unit: I set up a 'new creature discovery' in the school grounds (called a 'Linro') and the children had to investigate the creature (stick their hands in a papier mache model full of goop!), research its habitat, write a newspaper report then create their own animal, dress up/make it out of papier mache and produce an extended piece of writing based on their new animal's adaptations'. Also turning the predictable into something better, making the ordinary fascinating, seeing differently and maximising opportune moments.
Allowing for flexible beginnings	Response 1: 'sometimes the most creative lessons in terms of outcome tend to be less structured or less conventional (i.e. investigative play such as, "What can you discover if your given these electrical components[?], What's the most interesting thing you can do with a magnet[?]' Also valuing questions.

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a CIC**
Turning predictable outcomes into something better	Response 44: 'exploring methods of transporting the prince and his jewels (marbles) across the sea without sinking, looking at floating, sinking and density. Chn[*sic*] gathered their own ideas and created ways of recording to decide the best method of transportation' Also making the ordinary fascinating, seeing differently, modelling explanations and encouraging autonomy.

Making the ordinary fascinating	Response 70: ‘Testing the effect of air resistance - children made and tested spinners with paper clip weights on the end’. Only associated with making the ordinary fascinating.
Sharing a sense of wonder	Response 47: ‘We were looking at how plants grow and the children came up with lots of other liquids they wanted to feed their plants (other than water). From that, children asked if plants grew better depending on music being played via head phones through the pot and the vibrations into the soil. The predictions were many and varied with most thinking that calm classical music would enable the plant to grow faster than heavy metal. The children had to think very carefully about fair testing and in the end, though the music made very little impact as the only variable, the process stimulated lots of science talk and questioning about plant senses and even consciousness!’. Also turning the predictable into something better, making the ordinary fascinating, seeing differently, maximising opportune moments, valuing questions, modelling explanations, encouraging autonomy and allowing for flexible beginnings.
Seeing differently	Response 77: ‘Children had to come up with ideas for their own plant investigation. They generated their own questions such as do plants grow in glitter, jelly, water etc. They then predicted and tested their ideas out’. Also turning the predictable into something better, making the ordinary fascinating, valuing questions, modelling explanations and encouraging autonomy.
Maximising opportune moments	See response 47 when sharing a sense of wonder.
Humanising science	N/A
Valuing questions	See response 47 when sharing a sense of wonder and response 77 for seeing differently.
Modelling explanations	Response 24: ‘Space Glove experiment – chn[*sic*] tested which material provided the best insulation for an astronaut. In groups of 4 or 5, they decided how to test insulation and selected the materials they wanted to use. Then, they recorded their results and analysed them to discover which material would be the most effective’. Also Making the ordinary fascinating, seeing differently, modelling explanations and encouraging autonomy.
Encouraging autonomy	Response 31: ‘children plan and carry out an expt[*sic*] to separate a mixture of sand, salt, stones using knowledge of separating and dissolving’.

	Also modelling explanations.
Allowing for flexible beginnings	See response 47 above, sharing a sense of wonder.

APPENDIX 6.C: Notable examples of children when at their most creative in science (with Ann Oliver's ten ways to make science teaching creative in mind)

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a CCA**
Turning predictable outcomes into something better	Response 94: 'Creating the family of fundamental particles using plastic balls and adding appropriate weights using plasticine and features based on their characteristics - a wonderful introduction to the work going on at CERN and what all the particle physics is about'. Also making the ordinary fascinating, seeing differently and modelling explanations.
Making the ordinary fascinating	Response 28: 'Designing a machine to brush a dinosaur's teeth' Also making the ordinary fascinating and seeing differently.
Sharing a sense of wonder	Response 35: 'Our y3 are trying to work out if clouds make a shadow - some are not at all sure, which is encouraging others to try more and more ideas to convince them'. Also making the ordinary fascinating, seeing differently, maximising opportunities, valuing questions, encouraging autonomy and allowing for flexible beginnings.
Seeing differently	Response 9: 'Human flow charts presented in different ways for life cycle of frog/butterfly'. Also making the ordinary fascinating and modelling explanations.
Maximising opportune moments	Response 15: '…lots make mistakes, but we then discuss issues arising and they help each other with ideas'. Only associated with maximising opportune moments
Humanising science	Response 10: 'Asked really big questions about the beginning of the universe where there is currently only ideas'. Only associated with humanising science
Valuing questions	Response 96: 'Coming up with questions during science enquiry sessions and working out ways to answer them. Offering creative suggestions to improve enquiry and not being afraid to get things wrong!'
Modelling explanations	Response 44: '…slime races creating different types of slimes, making predictions on which slime would move the quickest and having a race to

	find out, we then wrote reports on the slime race'. Also making the ordinary fascinating, seeing differently and modelling explanations
Encouraging autonomy	Response 40: 'Planned and carried out own mini beast investigations - everything from finding out whether earthworms can smell to seeing which habitat a snail prefers'. Also turning the predictable into something better, making the ordinary fascinating and seeing differently.
Allowing for flexible beginnings	See response 35 to sharing a sense of wonder above

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a TIC**
Turning predictable outcomes into something better	N/A
Making the ordinary fascinating	Response 13: Our first lesson on rocks this term - I brought in 7 rocks (one each) and gave the pupils a load of craft resources including googly eyes and challenged them to each make a member of a 'rock band'. They had to choose a name for their rock based on texture, weight, size colour etc. Really effective introduction to rocks!' Only associated with making the ordinary fascinating.
Sharing a sense of wonder	N/A
Seeing differently	N/A
Maximising opportune moments	N/A
Humanising science	N/A
Valuing questions	Response 26: 'Within the Science fair I have had which type of water allows plant to grow best, what is the best formula for salt dough to conduct electricity, how to make plastic from milk.' Also encouraging autonomy
Modelling explanations	Response 65: 'Mad scientist came in and did super experiments with the children, created elephant toothpaste.' Also making the ordinary fascinating.

Encouraging autonomy	Response 49: 'I did try and provide lots of 'space' for children to follow their own ideas; of course that space was often used to just mess around (nothing wrong with that in my opinion but increasingly difficult in the current climate)' Only associated with encouraging autonomy.
Allowing for flexible beginnings	Response 4: 'Allowing children to independently investigating the different food groups and challenging them further by making them think about how some foods belong to two or three food groups (i.e. milk is a fat and a protein).' Also associated with encouraging autonomy.

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a CIC**
Turning predictable outcomes into something better	Response 8: 'Followed their own ideas/questions to put working lights into their hamster cage: - solar linked'. Also turning the predictable into something better and valuing questions.
Making the ordinary fascinating	Response 59: 'During a lesson on light and expecting the children to use mirrors, one child came up with the idea of putting water into a plastic bottle then piercing a whole in the bottle and shining a light through the running water to change the direction or the light' Also turning the predictable into something better, seeing differently, modelling explanations and encouraging autonomy.
Sharing a sense of wonder	N/A
Seeing differently	Response 39: 'Recently we looked at the five areas of animals where the children were encouraged to create their own poster etc of this. They created some great and different ways of showing this. Some created basic posters, others created 3D models and others made pop-up books'. Only associated with seeing differently.
Maximising opportune moments	Response 73: 'When making parachutes to look at forces, some of the Year 2 children decided to explore manipulating a piece of paper to change the strength and shape of it by scrunching it up and re-opening it'. Also turning the predictable into something better, making the ordinary fascinating, seeing differently and modelling explanations.

Humanising science	N/A
Valuing questions	Response 35: 'Whilst investigating 'how to make a worm smile' one pair abandoned the two choices in a tray fair test set up that all the others chose in order to do an observation of worm response to noise over time. Simple, but totally their own choice when they realised a fair test wouldn't suit their idea. I've also enjoyed watching a child spend the whole afternoon trying to make a paper clip weighted parachute fall faster using magnets. He solved one problem after another to refine his experiment. Most lessons have a 'wow' child / moment, but it's hard to single one out. Our y3 are trying to work out if clouds make a shadow - some are not at all sure, which is encouraging others to try more and more ideas to convince them'. Also turning the predictable into something better, making the ordinary fascinating, seeing differently, maximising opportune moments and encouraging autonomy.
Modelling explanations	Response 74: 'Left to her own devices, one of my middle ability pupils noticed the difference on the brightness of bulbs in series and parallel circuits, testing what she'd found out by borrowing resources from other tables to add five or six bulbs to double check what she'd noticed'. Also turning the predictable into something better, making the ordinary fascinating, seeing differently, maximising opportune moments and encouraging autonomy.
Encouraging autonomy	Response 48: 'Developed their own investigations to test a theory. They were given a statement and had to design and carry out their own investigation using any equipment they thought was the best suited for the job. They then had to fully conduct the investigation and present their findings in a way that a younger child would be engaged in and understand'. Also turning the predictable into something better.
Allowing for flexible beginnings	Response 29: 'Year 2 children devise their own individual experiments relating to growing plants. The children set up the investigation as independently as possible from the planning stages through to carrying out the investigation and then reflecting on their learning. They choose the seeds to grow, how to record, what to do etc'. Also encouraging autonomy

APPENDIX 6.D: Noteworthy instances of children at their most creative in disciplines other than science (with Ann Oliver's ten ways to make science teaching creative in mind)

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a CCA**
Turning predictable outcomes into something better	Response 18: 'Being creative in art. The children have used a variety of different ways to create shades of colour and lines. Great results, everyones was so different: rainbows, stripes, pictures etc..'. Also making the ordinary fascinating and encouraging autonomy.
Making the ordinary fascinating	Response 6: 'Deviating from plan when making composter - using alternative ingredient- pencil sharpenings etc. Sticking post-its on it with uses of advanced punctuation previously taught in class!' Also turning the predictable into something better, maximising opportune moments and allowing for flexible beginnings
Sharing a sense of wonder	Response 25: 'Created an invention that would be made 100 years from now'. Only associated with sharing a sense of wonder.
Seeing differently	Response 54: 'We looked at different types of natural resources. The children spent ages working with them and creating different pieces of artwork'. Only associated with seeing differently.
Maximising opportune moments	See response 6 when making the ordinary fascinating
Humanising science	Response 42: 'Imaginatively reflected on Creation using any media of choice'. Also making the ordinary fascinating, sharing a sense of wonder, valuing questions and encouraging autonomy.
Valuing questions	See response 42 to humanising science.
Modelling explanations	Response 9: 'Fire of London water chain to collect most water in container to help them reflect on fire-fighting strategies'. Also making the ordinary fascinating.
Encouraging autonomy	Response 5: 'Making sculptures including transparent, translucent, opaque, fluorescent and reflective materials to create different shadows and patterns when they are displayed on a sun-lit windowsill. Some amazing

	models!’ Also making the ordinary fascinating and modelling explanations.
Allowing for flexible beginnings	See response 6 when making the ordinary fascinating.

Oliver’s ten ways to make science teaching creative	**Teacher descriptions of a TIC**
Turning predictable outcomes into something better	N/A
Making the ordinary fascinating	Response 28: ‘I once did a whole unit of work on a desert island shipwreck where my whole class created a huge desert shelter on the school field... that was pretty creative as they had very little usable materials and had to think/work together to turn natural materials into a sturdy shelter!’ Also encouraging autonomy.
Sharing a sense of wonder	N/A
Seeing differently	N/A
Maximising opportune moments	N/A
Humanising science	N/A
Valuing questions	N/A
Modelling explanations	N/A
Encouraging autonomy	Response 15: ‘DT...moving toys….lots of resources given and then after cams assembled ch[ildren] to create the characters, background etc themselves’. Only associated with encouraging autonomy
Allowing for flexible beginnings	N/A

Oliver’s ten ways to make science teaching creative	**Teacher descriptions of a CIC**
Turning predictable outcomes into	Response 47: ‘My present class have created video portraits of themselves both filming/questioning each other and filming themselves. These allowed

something better	children to express themselves in many different ways from rap or songs about themselves to taking cameras for walks and narrating to photographing emotions. Some pairs made mini films about their friendships'. Also turning the predictable into something better and making the ordinary fascinating.
Making the ordinary fascinating	Response 22: 'investigation and presentation of the local area - children chose a variety of ways to report back - poems, song, sketch, brochures, combinations of previous - solo and joint efforts' Also turning the predictable into something better.
Sharing a sense of wonder	N/A
Seeing differently	Response 80: 'Child-initiated den-making, in the book corner. My children used cardboard tubes as rafters and spent some time 'tiling' the roof using all the books from the shelves, and decorating their new house. Lots of discussion and teamwork when it came to putting the tiles in the right places so they didn't fall through the rafters'. Also turning the predictable into something better, making the ordinary fascinating and encouraging autonomy.
Maximising opportune moments	N/A
Humanising science	Response 67: 'Imagining they were a soldier in world war one after exploring artefacts (including medals that the children had brought in from home) and writing a letter home to their loved ones - very moving - especially considering they were just in year 2 and many of them were still 6 years old'. Also seeing differently
Valuing questions	N/A
Modelling explanations	N/A
Encouraging autonomy	Response 8: 'Create their own song - taught themselves to play guitar'. Only associated with encouraging autonomy
Allowing for flexible beginnings	N/A

APPENDIX 6.E: Aspects of a teacher's practice that ignite children's interest in science (with Ann Oliver's ten ways to make science teaching creative in mind)

Oliver's ten ways to make science teaching creative	Teacher descriptions of a CCA
Turning predictable outcomes into something better	Response 73: 'Sometimes simple investigations to develop observational skills, lighting a candle, making a cup of tea, letting a[n] inflated balloon go. How many things can they see and challenge them to come up with more than 10'. Also making the ordinary fascinating, seeing differently and modelling explanations.
Making the ordinary fascinating	Response 91: 'During our planet earth topic we sang and also composed a variety of songs about the solar system'. Also making the ordinary fascinating.
Sharing a sense of wonder	Response 33: 'WOW introductions that give the chance for children to discuss what they think has happened and why then to explain it to the rest of the class'. Also seeing differently, modelling explanations and encouraging autonomy.
Seeing differently	Response 15: 'Being active, getting stuck in! Making mistakes, learning from them and sharing ideas'. Also maximising opportune moments and encouraging autonomy.
Maximising opportune moments	Response 37: 'Very often we would research things together. Often children would find information and share it in class. This open approach definitely helped spark interest'. Also valuing questions, encouraging autonomy and allowing for flexible beginnings.
Humanising science	N/A
Valuing questions	Response 37: 'The children had opportunities to write anything that they wanted to know about the subject matter and each question was answered during the time we learnt that particular topic'. Also maximising opportune moments, valuing questions, encouraging autonomy and allowing for flexible beginnings.

Modelling explanations	Response 13: 'Plants - roots. Using food colouring and white carnations to show how plants drink water from the bottom up'. Also making the ordinary fascinating, seeing differently and modelling explanations.
Encouraging autonomy	Response 52: 'Open ended questions e.g. are people taller than the distance from their finger tips on their left hand to their finger tips on their right hand? Also spark their interest because they want to find out'. Also turning the predictable into something better, making the ordinary fascinating, modelling explanations and valuing questions.
Allowing for flexible beginnings	Response 49: 'a child brings a pumpkin in & you spend time cutting it up exploring it, making soup & noticing the changes playing with the seeds'. Also maximising an opportune moment and making the ordinary fascinating.

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a TIC**
Turning predictable outcomes into something better	N/A
Making the ordinary fascinating	Response 38: 'Hands on, having something to spark their ideas especially for writing, I'm keen on using props to inspire'. Only associated with making the ordinary fascinating.
Sharing a sense of wonder	Response 52: 'Challenging what they believe to be true by making something "magic" happen e.g. magnets and 2p coins or adding milk to oil or vinegar to bicarbonate of soda'. Also making the ordinary fascinating.
Seeing differently	Response 49: 'I think that it is the combination of their interests & being to take them somewhere new too. Only associated with seeing differently
Maximising opportune moments	Response 57: 'The fact that all ideas are valued and that the lesson can and does change depending on what the children are offering me'. Only associated with maximising opportune moments
Humanising science	N/A

Valuing questions	Response 46: 'Sometimes I use a short video clip, or maybe a piece of music, or a visual image to get them thinking and generating questions about a particular topic. They seem to like the unpredictability!' Also making the ordinary fascinating, sharing a sense of wonder, encouraging autonomy and allowing for flexible beginnings
Modelling explanations	Response 61: 'Children having guidance through modelling but then crating their final outcome themselves'. Also encouraging autonomy.
Encouraging autonomy	Response 74: 'Children enjoy practical lessons starters, where they're asked to predict or think about a what might happen before a short/fun experiment, e.g. observing what happens when the 7 colours of spectrum on a spinner are spun at speed - being surprised that they see white as the introduction to our work on how we see light'. Also modelling explanations.
Allowing for flexible beginnings	See response 46 for valuing questions.

Oliver's ten ways to make science teaching creative	**Teacher descriptions of a CIC**
Turning predictable outcomes into something better	Response 60: 'The children finding out answers to their own questions through trial and error experiments/investigations'. Also valuing questions and encouraging autonomy.
Making the ordinary fascinating	Response 97: 'the children are very often following their own lines of enquiry and interest about a topic, choosing for example which animals they would like to learn about, design, make, write a poem about etc'. Also turning the predictable into something better and encouraging autonomy.
Sharing a sense of wonder	N/A
Seeing differently	Response 66: 'Discovering things for themselves, especially when they have made assumptions about the results and are totally surprised'. Also encouraging autonomy.
Maximising opportune moments	N/A

Humanising science	N/A
Valuing questions	Response 60: 'The children finding out answers to their own questions through trial and error experiments/investigations'. Also turning the predictable into something better and encouraging autonomy.
Modelling explanations	N/A
Encouraging autonomy	Response 39: 'The children love being given independence in their learning and work. This gives them chance to use their own creativity. Some need support, but others enjoy the challenge of trying new ways of showing off their learning', Also turning the predictable into something better and seeing differently.
Allowing for flexible beginnings	N/A

APPENDIX 6.F: Quotations relating to why teachers believe being creative is difficult in a science lesson (from most prominent to least common)

Themes	**Quotations**
Resources	Response 24: '…school resources are not great and I often have to buy the resources with my own money'.
Time	Response 28: '...in my opinion, as we are short on time for science and so we spend the little time we have cramming 'knowledge' in rather than exploring science more creatively'.
Space	Response 78: 'I would love to teach groups of about 12 in a lovely creative space, not a desk-ridden room! Never will happen!!'
National Curriculum	Response 1: 'We keep being told that the new curriculum is flexible but in reality it is one huge tick list of things to get done in very little time'.
Adult support	Response 18: '...sometimes creativity might require support from adults prompting questions/responses and allowing more, slightly risky investigations of creativity to happen…'.
Class size	Response 3: '...adult to child ratio large number of children 30+ '. Response 37: 'Large number of children in class does pose a problem because of the excitement that practical activities bring with it'.
Behaviour	Response 25: '...staff feeling like they lose control slightly if children allowed to be creative and think of investigations themselves'.
Assessment	Response 1: '...the obligation to get down "evidence" (such as using ICT, bar charts, filling out tables, diagrams) gives children fewer moments to experience science purely for the fun of it'.
Pedagogical Content knowledge	Response 92: 'Having the confidence to know you have covered the content required for science'.
Rigidity of Structure	Response 93: 'Lessons being knowledge driven rather than skill driven…Pre determined outcomes from teachers'.
Health and Safety	Response 45: 'In depth risk assessments if you're using fire (even lighting a candle)'.
Policy makers	Response 33: 'Outside of school pressures to achieve targets set by people who have little to no understanding of how primary schools work'.
Ofsted	Response 20: 'Ofsted will not approve of the learning /teaching method or style'. Response 68: '….having to write every lesson (school policy post Ofsted)'.
Mess	Response 100: 'Making too much of a mess'.
Thinking skills	Response 5: 'Getting non-scientists (adults!) to understand how scientists think'.

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APPENDIX 6.G: Illustrative quotations which reveal teachers' perceptions of why children find it difficult to be creative during a science lesson (from most prominent to least common)

Themes	Quotations
Worried or fearful	Response 25: 'Children fairly used to being given instruction and the freedom to choose themselves may be daunting…Fear of getting an answer 'wrong' - they are not keen on estimating and like to be right all of the time'.
Rigidity of Structure	Response 29: 'Science can be seen as quite prescriptive in relation to working scientifically so teachers may feel that they need to direct and guide every stage instead of letting the children take ownership of their learning'.
Getting the answer right	Response 18: 'The children do not always feel that they can be creative, that they must be correct and are afraid to be wrong'. Response 34: 'I think they see science very much like maths where there is a right or a wrong answer'.
Life experience	Response 1: 'Very few life experiences meaning that connections with the outside world are not made, they have to be made FOR the children'.
Time	Response 98: 'Children need to be given time to develop a creative mind and harness critical thinking skills - it is something that needs to be developed over a long time'.
National Curriculum	Response 1: 'Boring statutory approaches that are forced on children in an attempt to make them appear to be "working scientifically"'.
Confidence	Response 40: '…confidence can lead to certain pupils taking over and stifling the creativity of others in the group…'.
Lack of knowledge	Response 75: 'Their scientific knowledge can be quite poor and this lack of understanding means they struggle to be inventive'.
Interest	Response 26: '…some just do not have the interest'.
Domineering children	Response 3: 'As many science activities are carried out in small groups dominant characters often take over'.
Resources	Response 24: 'The experiments are more closed because of limited adults, resources and time'.
Practical experience	Response 7: 'Teachers not allowing children freedom to think or do practical activities'.
Difficulties in generating ideas	Response 10: '…not all staff are confident enough to let the children lead with some of their ideas'.
Thinking skills	Response 98: 'Children need to be given time to develop a creative mind and harness critical thinking skills - it is something that needs to be developed over a long time'.

Assessment	Response 60: 'Onus on writing up everything!!! Evidence should be through a range of media not just writing up'.
Space	Response 78: 'Lack of space'.
Types of questions being asked	Response 52: 'A lack of open ended questions'. Response 17: 'Some pupils are huge fans of black and white, closed, right or wrong questions'.
Preconceptions	Response 91: 'They have a preconception that science is a 'hard' and serious subject'.
Health and Safety	Response 70: 'H&S restrictions imposed'.
Adult support	Response 24: 'The experiments are more closed because of limited adults, resources and time'.
Evaluating ideas	Response 5: 'Lack of reflection'.
Imagination	Response 44: '…imagination has not been stimulated enough'.
Domain specific	Response 29: 'Some may have the view that being creative is art, drama or poetry only'.

APPENDIX 6.H: Teachers written descriptions of the aspects of students thinking which are not measured through summative assessment tests (from most prominent to least common)

Themes	Quotations
Thinking skills	Response 16: '...evaluating, critiquing, synthesising.' Response 98: '...analysing information and using it to solve problems / find solutions'.
Working Scientifically	Response 1: '…aspects such as questioning, creating experiments, choosing the correct equipment, researching, presenting findings (just to name a few) would not be measured'.
Creativity	Response 18 'Using summative tests asks for specific answers and children are often taught to respond appropriately to a test, which does not encourage creativity'
Questioning skills	Response 76: '...their ability to create and ask questions'. Response 9: 'Freedom to give more ambitious answers that don't necessary tick the right boxes'.
Risk-taking	Response 79: 'Errors, and the incidental learning that might come from it'.
Reasoning skills	Response 33: 'Scientific reasoning'.
Discussion/talk	Response 62: '...thought processes developing as a result of discussion'.
Making connections	Response 53: '...linking different topics and aspects of science together and to real life Situations'. Response 49: '...making connections between areas of learning might be missed'.
Conceptual understanding	Response 20: 'Deep understanding and ability to link or transfer knowledge/skills'. Response 46: '...their ability to relate what they have found out related to scientific principles at a deeper level'.
Imagination	Response 86: '...imagination'.
Autonomy	Response 52: 'Their need to find things out for themselves rather than be told'. Response 74: 'Their ability to think for themselves and explore/wonder "what if?"
Everyday knowledge	Response 99: '…to relate something in their learning to other contexts, make wider predictions..'.

	Response 40: ‘Links with existing knowledge/ personal experience - need to draw these out according to individual child’.
Group work	Response 59: ‘...how they work as a team’.
Resilience	Response 80: ‘...description as well as their persistence in the face of a difficult task’.
Curiosity	Response 52: ‘Their curiosity rating. Their need to find things out for themselves rather than be told’.
Flexibility	Response 28: ‘…flexibility’.
Assessing progression	Response 78: ‘...practical assessments to assess progress’.

APPENDIX 6.I: Teachers written descriptions of formative assessment with Wiliam's five key strategies in mind (from most prominent to the least common)

Wiliam's (2011) five 'key strategies' of formative assessment	**Quotations**
Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning.	This section is thematically analysed into further sub-themes (see figure 6.6).
Activating learners as the owners of their own learning	Response 57: 'Children also complete e-portfolios or Learning logs independently where they can highlight learning events or activities which have captured their imagination particularly and these often illuminate the learning for me as a teacher after the event and sometimes enhance or contradict what I think I'd observed'.
Providing feedback that moves learning forward.	Response 97: '…using appropriate questioning techniques to probe children's understanding and, more importantly, respond to their ideas to move their learning forward'.
Activating learners as instructional resources for one another.	Response 39: '…using questioning from staff as well as peer support. This is especially the case when higher ability children support and question lower ability'.
Clarifying, sharing and understanding learning intentions and criteria for success	Response 97: 'Each session has a clear learning objective presented as an 'I can' statement. This provides the children with the opportunity to self-evaluate at the end of each session and to be involved in the setting of their individual and group's next steps for learning if appropriate'.

APPENDIX 6.J: Sample excerpts from the survey indicating who is initiating the assessment strategies

Who is initiating the assessment strategy	Quotations
FAS	Response 21: 'Because it [the assessment strategy] records their thinking which is often more advanced than their writing/ability to put into practice their ideas'. Response 59: 'It removals formal barriers of having to write a lot especially with those children who struggle with writing'.
Teacher-initiated	Response 29: 'As the teacher, you need to be able to find out what their thoughts are. Not all children can explain this well enough in writing, particularly at 6 and 7 years Old'. Response 75: 'The use of teacher observation, discussion and AfL allow the class teacher to encourage children to expand on their ideas and to develop their creative Thinking'.
Child-initiated	Response 3: 'The children are practically trying out their ideas. If something doesn't work they retry and think again to find a solution'. Response 98: '...it is not based on what the teacher / test provider wants you to know but rather on what the child got out of a unit of work - what did they deem worthwhile/ interesting that has stuck with them. It also allows students to measure what they have learned as it pre-assesses knowledge prior to the topic and what they know at the end of it so students themselves can see their own self growth'.

APPENDIX 7.A: Examining the teachers' responses, in case C, to the pupils answers, when they've been asked 'How do you know I'm alive?'

The questions asked by the teacher are colour coded and *italicised* (see key below). There are a number of times when the students name is asked and this, I have interpreted as the teacher restating the initial question.

Colour coding below represents how I have interpreted the teacher responses to the pupil's answers.

Key:
Responses to question *'How do you know I'm alive?'* are:
Orange: To do with the running of the lesson (Managerial).
Blue: Elaboration (through reflection).
Red: Repeated/paraphrased.

Teacher:	So I want you to turn to the nearest clean page in your books and I have a question, just to get us started. M. the book you were using this morning you can write in that, okay, I think it's over on the side. Okay, so here is the question and individually, so it's a think pair share, so I shouldn't hear anybody talking. Is it over on the side, I think Donna put it there, yep the yellow one. *How do I know I am alive?* (.) Okay. So I'm just going to give you a few minutes individually. (63 secs) Okay, I'm going to give you thirty seconds. (26 secs) Okay, talk to the person next to you or a group of three. *How do you know you are alive?*
	[…Children talk to one another…]
Child 1:	Most living things have a pulse ( )
Teacher:	Is that true?
Child 1:	Most of the time, like that is, but trees are alive.
Teacher:	Do they have a pulse?
Child 1:	No, (but) most, but it's not living.
Teacher:	(3 secs). Okay keep going with your ideas.
Child 1:	Um.
Child 2:	You know the thing (are like) changes, um. All living things go through changes. They don't look like, stay the same throughout their (.) life.
Child 3:	(6 secs) If you're dead you might change.
Teacher:	Is there a difference between (.) between being dead and being (.) not a living thing?
Child 4:	Yeah but […teacher talks over child…]
Teacher:	For example F., this table is clearly not alive.
Child 5:	It can't move.
Teacher:	But does that mean its dead?
Child 6:	Um.
Teacher:	So are you either alive or dead. Er, is everything in the world, could we have it as alive or dead or is it living or not living? Er I don't know.

Child 7: ( ) (.) That's a hard question.

Teacher: That is a hard question isn't it. (.) But one of the things you said, er, a minute ago about movement was interesting

[…Children continue to talk to each other…]

Teacher: Okay. So we've had a think, we've had a pair, let us have a share. (3 secs) Okay, so, just before we share let's just re-establish what the rules are, so if you've got something to say you put your hand up; if you disagree with somebody you don't point at them a shout at them and say your rubbish, you're wrong, you say excuse me, I'm going to challenge you. Okay, so E. kick us off. *How do you know you're alive?*

Child 8: Um, you feel your pulse.

Teacher Okay, I'm gonna, I'm going to ask you a question back. Do all living things have a pulse? (3 secs) I'm going to leave you to think it. Just asking you a question back. E. *How do I know I'm alive?*

Child 9: Senses, so like you can feel things, you can see things, you can touch things and taste things.

Teacher: Okay, I'm going to ask you back the same question. Does a tree touch things, taste things, see things, hear things? But a tree is alive. I'm going to live you with that thought. *W.*

Child 10: You're breathing.

Teacher: Okay. (.) Do all living things breathe? I know you breathe, but if I was too extend the question how do I know I'm alive, if I'm a tree is breathing going to be one of the things makes me know I'm alive? (3 secs) You're pulling, you're pulling I'm about that one face. *R.*

Child 11: I know I'm alive because (.) the (way I make something move).

Teacher: Because I can move. Right, okay, you like that one. *F.*

Child 12: Cause most, most living things they like grow.

Teacher: So I know I'm alive because I grow.

Child 12: Dead things, cause, cause skeletons they just stay the same when their dead, don't they. They just rot away.

Teacher: Yeah.

Child 12: They stay there the same shape as your normal body will die and a table can't grow. Ah, but we grow, trees grow ( ) grow […teacher talks over child…]

Teacher: Okay. F. and I just had a really interesting conversation, um. Is there a difference between (.) the, so've you got things that are living and you've got things that have never been alive but does that mean that their then dead? (5 secs) Hold that thought, hold that thought because we're going to end up going for, in a funny directions. *M. How do I know I'm alive?*

Child 13: Well normally something notices you, something looks at you, when you're alive. Something knows that you're there.

Teacher: So what you're saying M. is that if you're alive you have a kind of impact on your environment.

Child 13: Yeah.

Teacher: Okay, and some of us have more of an impact than others don't we. Er, *T.*

Child 14: ( ) because like (having) said, like they see you but they sort of see you when you're dead as well. Cause like if you just lay down dead then someone will see you and they're gonna make, take more attention because you're dead ( ).

Teacher: What so all those dead people there just attention seeking.

[…teacher and children laugh…]

Child 14: But if there was a dead person who was laying down in the street […teacher talks over child…]
Teacher: They would have, it would have an impact wouldn't it?
Child 14: Yeah.
Teacher: Yes, Yeah I can, I can see why you're arguing, I can. *M*
Child 15: Um, ( ) I can think.
Teacher: You can think. Okay, I can see that to be true in a human and I can kind of see that to be true in an animal. Um. Just thinking about your dad, okay, now your dad he's got his dogs that he's training in front of him, when he gives a certain command there's something in the dogs brain that thinks I know that command and I know what I've got to do, so we're saying dogs can think. Um, do trees think?
Child 16: Yeah, yeah they do.
Child 17: Nobody knows
Teacher: Nobody knows okay. Um. Okay, let's have somebody. *J. How do I know I'm alive?*
Child 18: Um, well because it has to be too much dead ( ) I think really ( ), it's just like
Teacher: Ohh.
Child 18: ( )
Teacher: So are things either dead or alive? Or (.) have been alive? Or have never been alive?
Child 18: Yeah, being dead, not really existence, because if there […teacher talks over child…]
Teacher: But this table exists, cause I can touch it. It's a really hard question isn't it? *E.*
Child 19: Um, if you're alive you can change.
Teacher: So if you're alive you could change.
Child 19: Cause like in, in a tree there were like, they can change
Teacher: (.) Does that link with; somebody said about growing and moving. Okay. I'm going to take one more and then we're going to move on. *L.*
Child 20: Um, most liv, all living things eat
Teacher: All living things eat, okay.

Case C: Excerpt 7.1

To be continued……

This page is dedicated to Harry……

He always did like to have the last word!!

'We are the Ovaltineys…' (Spooner, 1925-2014).