Exploring secondary school science teachers' understanding of creativity in their lessons.

A thesis submitted by Gareth L. Price in consideration for the award of a PhD

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Abstract

This study uses a Personal Construct Theory methodology to explore the constructs of creativity of science teachers working in England with students aged 11-16. In-depth interviews were conducted with 7 UK teachers on two occasions to elicit the constructs they used to recognise creativity in their classroom context. 46 constructs were elicited and sorted into six categories: autonomy, optionality, collaboration, confidence, efficacy and excitement. These categories were further sorted into 3 roles (Enablers, Modifiers and Validators) which allowed a model to be developed showing how the categories interrelated and could drive changes in teacher constructs and perceptions.

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Preface

P.1 Introduction

This preface is personal and reflective. It contains two narratives: one is a personal story of my journey from school teacher with a set of naive assumptions about creativity, through a growing interest as an author, curriculum developer and on to this study as an educational researcher. The other describes the development of this project showing a shift in emphasis from curriculum development and teaching techniques to a desire to explore others' understand of creativity with consequent changes to methodological approaches and expected outcomes.

Through this preface I hope to show how my experiences as a learner, teacher, author, publisher and curriculum developer have led me to this place and, perhaps, to secure some sympathy for where I now find myself: considerably older, marginally wiser and with many hours of recorded interviews with interesting science teachers.

P.2 A personal journey

P.2.1 Teaching at Countesthorpe College

This study is an outgrowth of a personal interest in creativity in science education. As a newly qualified teacher in Leicestershire in the 1980's, I worked at Countesthorpe College, described by Joanna Mack in New Society (10 June 1976) as 'the most thoroughgoing experiment in state secondary education in this country.'

My whole experience there, from the initial job interview (conducted partly by students) through to my final role as Head of Science (submitting the first Science GCSE created by a group of schools rather than a national Awarding Body), did nothing to make me doubt Mack's view. Staff at the college reserved the right to question and do things differently. This attitude was held in common from the college's first principal, Tim McMullen, to the most recently appointed probationary teacher.

> 'We have the chance to rethink the total process of learning within a school, subject only to the demands made by outside institutions - i.e. universities and parents - and the personal resources available to us. This does not mean everything we do will be different from what has been done before, but it should mean that we do not automatically repeat an established practice without considering why.' Tim McMullen quoted in *The Countesthorpe Experience,* p33

In everyday practice this mandate to 'rethink the total process of learning' meant that I was called by my first name by students in my Tutor Group, negotiated their personal curricula with them (no subject was compulsory but almost everyone followed the core of science, mathematics, English and humanities) and acted both as their teacher (the source of academic support) and their tutor (responsible for all pastoral care). Unusually for science teachers, even at Countesthorpe, I also taught English and Humanities to my tutor group and so operated as a generalist teacher with 25

students aged 14-16 years of age rather than as a specialist secondary science teacher responsible for science classes across a school.

It felt like, and was, an unusual school to work at. It had been heavily criticised by the local press (the front page of the local paper, the *Leicester Mercury,* called for a full public inquiry into the school in April 1973) and was the subject of a controversial ITV World in Action documentary and so, perhaps as a defence against the criticisms, staff tended to rejoice in being different to other schools in the area. With every new worksheet I wrote about the poems of Ted Hughes or Ohm's Law and every new approach to covering pH or the factors affecting employment prospects for different ethnicities in Leicester I felt innovative, different, edgy and 'creative'. This was 'creativity as constant change'.

However, this view of creativity included elements of 'change addiction'. I found nothing so exciting and motivating as 'a new way to do *x*' or 'a different take on *y*' which I equated with creativity. There was also an unhealthy sense of elitism, being a bit 'ahead of the field' and 'cutting edge' which allowed us to hail everything as a success - it was 'different' and 'innovative' so it must be a triumph even when cooler heads might have admitted that, judged by examination results at least, the school was less than perfect. To be ahead of the crowd was to be above criticism.

Alongside this arrogance was a sense that other schools were probably not able to follow Countesthorpe anyway. They did not have the newly-constructed premises or the staff carefully selected to be on the progressive end of the teaching spectrum or even the relatively generous Pupil-Teacher Ratio. Quoted in *The Countesthorpe Experience* edited by John Watts (the principal of the college) a Times Educational Supplement (TES) journalist, Virginia Makins, sums up the first five years at the college recognising this success but also the special circumstances at Countesthorpe that made it possible.

> 'So, in many ways important ways, the experiment has been a great success. It remains to be seen how far it can be disseminated.' Virginia Makins, quoted in *The Countesthorpe Experience,* p50

Perhaps inevitably the college changed from its early radicalism into a more acceptable, if less exciting, institution as it aged. The arrival of Margaret Thatcher as Prime Minister in 1979 heralded a series of changes in the UK education system from funding cuts to the National Curriculum, increased testing of students and school league tables. These were not friendly to a progressive comprehensive state school. A new head teacher, a series of strikes and a court case involving two teachers from Countesthorpe College supplying drugs to an undercover police officer in a sting operation also drained the resilience of the school. We moved from being defiantly 'different' to defensively 'not too weird'.

At this point, my view of creativity was that it was delicate and needed support but given this support, or license, it could be disruptive - at least to those who wanted to be disrupted. Was creativity suitable for 'mainstream' schools in tough times? My heart said 'Yes' but my head was less certain.

P.2.2 Commissioning Editor at Collins Educational Publishers

After leaving Countesthorpe College in 1989, largely in response to changes forced on the school, I worked at Collins Educational, a major educational publisher based in London, where I was responsible for writing and commissioning science, technology and mathematics textbooks for secondary level in the UK. Again, there was a clear sense of being on the innovative and creative end of the educational publishing industry producing new learning resources, in a variety of formats, to cover new content in the growing National Curriculum. Collins was the first publisher to produce textbooks in full colour for Key Stage 3 students (Active Science, 1994), the first to agree an endorsement deal with a UK Awarding Body (Collins Advanced Modular Sciences, 1999) and the first to produce full colour books for students operating at Entry Level at 16 (Science Plus, 1997). To me it seemed that these initiatives marked Collins out as an innovative company with other publishers following behind by publishing similar schemes.

However, while some schemes were highly successful and became significant contributors to company profits, a few did not reach a single reprint and faded quickly from the market. This seemed to confirm the lesson from Countesthorpe: creativity (by which I meant innovation), by itself, did not appear to work in every case. Reflecting back I do not think I deliberately and consciously revised my understandings of creativity but I did begin to factor in acceptability or usefulness as a mark of a truly creative solution. The sales figures for two projects which, at publication, seemed to be equally innovative, could be very different and this made me reflect that innovation alone was not enough - particularly when creative ideas interacted with the rigid rules and requirements provided by the newly-launched National Curriculum, the tensions generated by school league tables and the requirements of teachers under pressure to deliver constantly rising results.

P.2.3 The Centre for Science Education, Sheffield Hallam University

I left Collins in 2003 and joined the Centre for Science Education (CSE) at Sheffield Hallam University. CSE was a body set up to encourage more students to engage with Science, Technology, Engineering and Mathematics (STEM) at school and beyond through curriculum development projects and Continuing Professional Development (CPD) for teachers. Although part of Sheffield Hallam University, CSE had a clear, separate identity as one of the largest curriculum developers in the UK and had a mission statement with the strapline ‘creativity that works’. In effect, CSE claimed to be ‘cutting edge’ but also capable of producing resources and developing curricula that ‘worked’ for students and teachers. Was this the place where my view of creativity could be refined?

This stimulated considerable personal reflection about the nature of creativity in science education alongside my understanding of teaching and learning. I was able to say confidently that I adopted a constructivist position (Driver and Oldham, 1986) with regard to student learning and was committed to making science somehow interesting or relevant to students. I could point to a

successful career teaching in a progressive school in Leicestershire, time spent as a commercial publisher, a series of school science textbooks and other resources (including software) at primary and secondary level with my name on the front cover and, at CSE, a chance to work with a university department that had the word creativity in its mission statement. And yet, I felt that my understanding of creativity in science education was limited to a few cliches and teaching techniques. This current PhD study grew, in part, out of that concern.

P.3 A PhD research project

P.3.1 Initial thoughts

When I began this study I hoped to produce a set of techniques for teachers to use to increase the creativity in their science students. These techniques would have been shown to be effective by research evidence including randomised controlled trials. The more I read about the importance, personally, culturally and economically, of creativity the more convinced I became that my study was worthwhile and even, potentially, important.

My personal history at Countesthorpe predisposed me towards collaborative working and a recognition, from my days as a publisher, that the only successful initiatives are the ones that people actually use pushed me towards an Action Research methodology. The chance to try something, reflect and modify and try again until the optimised solution was obtained seemed like an excellent way to hone my understanding of creativity, find out something of importance in science education and produce something useful for teachers and students.

However, the difficulties soon became apparent. There was much talk about creativity *about* science with advisors offering 'creative' activities such as posters, radio scripts, illustrated leaflets, discussion tasks and so on to describe or present scientific activity instead of the traditional lab write-ups. This was not quite the 'scientific creativity' I wanted to find. If it was 'teaching creatively' it was not 'teaching creativity' (Jeffrey and Craft, 2004) and certainly nothing about the process identified it as uniquely science - the creative poster could have been about the causes of the first World War or a summary of the views of students about the quality of school lunches. Alternative voices (Sternberg and Williams, 2003) offered more realistic suggestions to support creativity in lessons (e.g. Question Assumptions, Encourage Idea Generation, Build Self-efficacy) but again these did not apply specifically to science education and looked a bit like a return to Countesthorpe College's conception of 'good teaching' and student autonomy which had been effectively marginalised by government initiatives. To emphasise this problem 'creative' teaching could easily be confused with 'good' teaching in much of the science education literature (Kind and Kind, 2007) where progressive teaching techniques were often deemed creative while old-fashioned or didactic approaches were perceived as inevitably non-creative.

After a few months of false starts and limited progress, the central issue revealed itself as the nature of creativity in science education. This forced me to review my own understanding of the concept yet again and necessitated a shift in the proposed PhD study. My hoped-for quantitative

data about creative performance in school students was replaced with a more qualitative approach looking at the concept of creativity amongst science teachers. Initially I considered also involving school students in the study but the simple mechanics and limitations of a PhD study (time available, access to students) made this impractical so I chose to work with science teachers and explore their understanding of creativity in their science classrooms. This would, hopefully, help to develop my own understanding and, potentially, begin to uncover some of the issues concerned with science education and a 'creativity that works'.

P.3.2 Finding a methodological framework

The change from developing a pedagogical approach to improve creativity to an exploration of the meaning of creativity meant Action Research became a less comfortable fit. Initially I considered Grounded Theory (Glaser and Strauss, 1967) as a useful way to link systematic data collection and analysis to theory generation. It did not require an initial research question or an end-point specified in advance of data collection. These were attractive options given the complexity of the situation I was planning to explore. In the end I opened for an approach based on George Kelly's Personal Construct Theory (PCT) (Kelly, 1955) because it provided a clearer mechanism to explore the assumptions and preconceptions underlying teachers' understanding of creativity and was less likely to be hijacked by enthusiastic reports from teachers of established 'creative teaching techniques' like SCAMPER (Eberle, 1997) or any of the many creativity-enhancing techniques available from blogs and websites.

P.3.3 The project pathway

Describing a research project during the process can be difficult because a number of the decisions are made based on hunches and ideas that may not be immediately available to conscious analysis. Constructing a narrative at the end is only marginally less demanding. Post-event accounts could rationalise decisions according to outcomes and insights that were not available at the time and imply a much more strategic control than the experience might have suggested while living through it. Everything looks clearer in hindsight. With these caveats in mind, Figure Pr.1 is an attempt to reconstruct the development of this study. It finishes not at the end of this PhD but at the point when the approach was fixed: to use PCT methodology to look at teachers' understanding of creativity in their science classrooms. This thesis takes up the story from there.

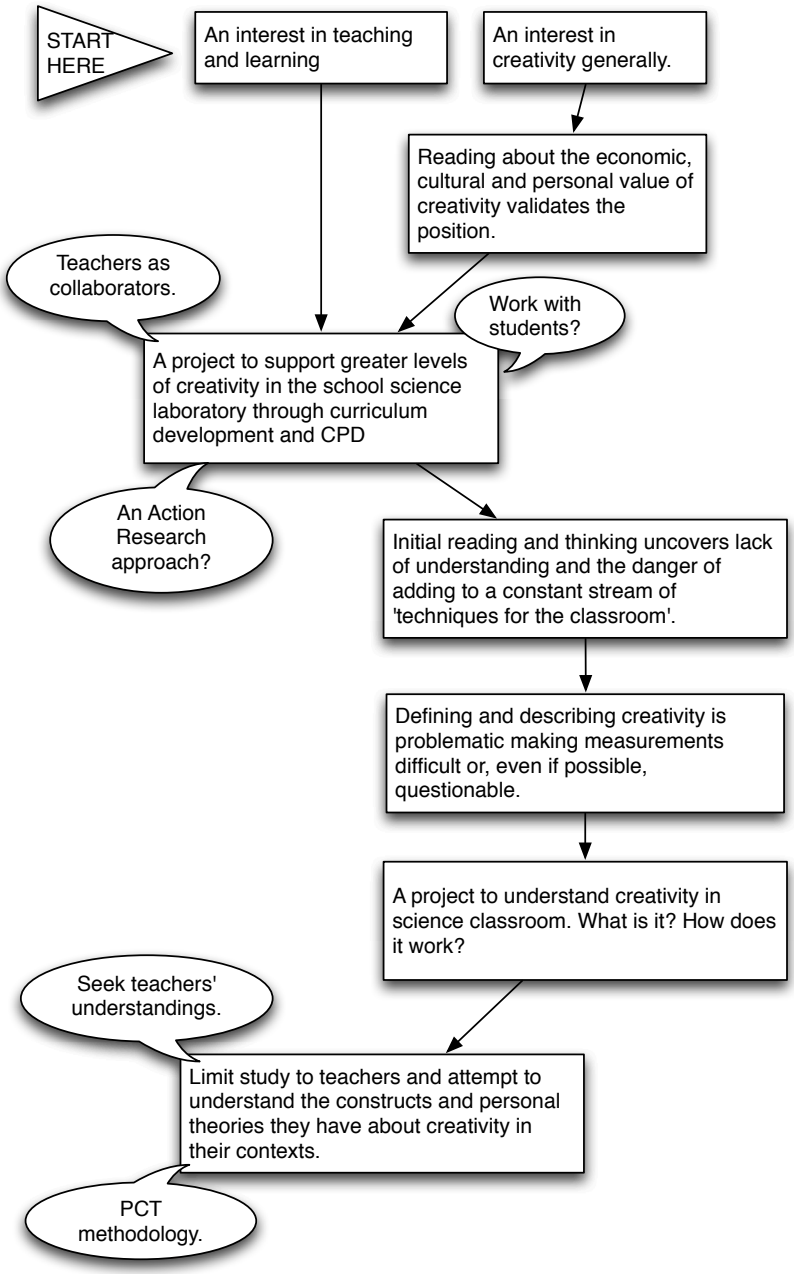

Figure Pr.1: An outline picture of the research project development

P.4 A working definition and a research question

P.4.1 A working definition of creativity in science education

In a study entitled 'Exploring how secondary school science teachers' recognise and experience creativity in their lessons.' it may appear surprising to start with a definition. Surely the point of this study is to find and understand how science teachers understand creativity? However, the definition given below is simply an attempt to show the area in which I expect to be working. It says as much about me as it does about science teachers' understanding of creativity and will be developed as the study progresses.

My understanding of creativity has developed from 'novelty' and 'being different' at Countesthorpe through to an understanding that creative products must have some generally agreed 'value' and be better than the traditional approach at Collins and even to the notion that creativity should 'work' (i.e. deliver greater engagement and achievement in students) at the Centre for Science Education.

This is in agreement with the vast majority of the available definitions of creativity which focus on these two features: novelty and value. Other writers have added other aspects like 'ethicality' (Cropley, 2001) or 'surprise' (Boden, 2004) but the two core features, 'novelty' and 'value', have remained constant. (Sternberg, 1999; Runco and Jaeger, 2012).

So, without pre-empting the discussion of the concept of creativity in Section 2.2, creativity must involve an activity that produces products that are novel and have some demonstrable value. Arguably education depends on a fundamentally creative activity because, in every lesson, students will, hopefully, create valuable new understandings (Bramwell *et al* (2011). In science education, the material covered (both the knowledge and the skills) should be broadly recognisable as belonging to the domain of science. This gives me my initial definition of creativity in science education.

> Creativity in science education involves the production of novel ideas, approaches or objects that serve some purpose or have some value in the context of engaging learners with, or developing, scientific domain knowledge and practices.

Note that this definition is tentative at this stage and begs as many questions as it answers. Who finds it novel? Who thinks it is valuable? And what qualifies as scientific domain knowledge? Rather than attempting to answer those questions formally at this stage the following statements are offered to clarify my current understanding and the outline definition above.

- Creativity in science education can include the production of ideas that would be recognisably scientific (e.g. testable claims about the rate of reaction of calcium carbonate with different particle sizes) or objects which communicate scientific insights generated elsewhere (e.g. posters, presentations, talks about experimental results of a science topic)
- Creativity in science lessons can be exhibited by teachers (in terms of novel pedagogical approaches) and students.

- The ‘value’ ascribed to creative outputs in science education will typically be focussed on student attainment or engagement.
- ‘Novelty’ in science education could mean ‘novel to the students’ as much of the material to be covered is already known within the wider scientific community. However, in some instances students will create insights or data that is novel on a wider scale.
- ‘Novelty’ could also mean ‘novel to the teacher’ where they are developing new teaching approaches but covering well-known domain knowledge.

Drawing on my definition and amplifications I suggest that the following would be characteristics of ‘creative science lessons’. These characteristics are discussed further in Section 2.4: Creativity in science education.

- Classrooms where teachers are supporting creativity with a strong focus on the production of new scientific ideas will typically require students to generate and test ideas routinely rather than just on special occasions for assessments. The teacher will similarly be naturally putting forward ideas and trying new things such as new practical procedures which will have been generated from first principles rather than found in teacher support manuals or online or be exploring novel ways to cover the scientific knowledge defined by the syllabus. Standards of work will be high with many students performing above their expected ability level and with many going on to study science at higher levels. Despite the apparently open nature of much of the discussion, expectations will be high - this is not just a class for dreamers. In many ways this is similar to classes following open inquiry approaches to science education (Bevins and Price, 2014)
- Classrooms where teachers are supporting creativity with a strong focus on the production of objects to communicate scientific ideas will be fun. Students will engage and enjoy the lessons and every lesson will be different. The learning resources will be of extremely high quality and students will make good progress. The teacher will be particularly good at drawing students into science and many will go on to study science at higher levels. Students will be involved in lots of group work and develop a range of ways to demonstrate their understanding including posters, presentations and models or exhibitions. They will enjoy the class and like their teacher who will typically be a ‘good performer’ and able to enthuse the students with a constantly changing diet of activities .

These descriptions are, inevitably at this stage, presumptive and look very like the kinds of lessons that many teachers would describe as simply ‘good science lessons’. This distinction may be problematic. I believe that ‘creative science lessons’ are, almost by definition, ‘good science lessons’ but some good science lessons, e.g. a clear and helpful revision session prior to a public examination, might be tightly structured with little room for the idea-creation activities key to creative lessons. The descriptions of ‘creative science lessons’ do not assume that teachers being creative and students being creative are mutually exclusive and many classrooms will offer an amalgam of both where the whole will be greater than the sum of the parts. It may be that following this research new aspects will be revealed as I engage in discussions with teachers and read the associated literature.

My research is setting out to explore, describe and theorise how science teachers recognise and experience creativity in their science classrooms. What do they understand by creativity as it applies to their lessons? I am planning to listen and seeking to understand, not to catalogue. This ambition is captured in the formal research question in the following section.

P.4.2 Identifying a research question

As this preface has made clear, there was no single research question at the start of the process. Indeed, much of the first part of the study revolved around finding a question that would focus on a key issue for creativity in science lessons without being so broad as to be answerable only in general or superficial ways, for example a catalogue of 'creativity techniques' and teaching approaches for science teachers to deploy. The research question below can thus be viewed as both a question to be answered and as a statement (however grammatically incorrect!) of what I now think is critical to really understand about creativity in science classrooms at secondary level in the UK.

- **What do secondary school science teachers understand by creativity in their classrooms?**

The word 'understand' perhaps needs some unpacking. I do not mean 'What do teachers say when asked 'What does creativity mean in your classroom?' '. It is not an invitation to provide a simple definition - many definitions are already available (Sternberg, 1999) and a working definition optimised to science education is provided in the previous section. It is an opportunity to explore how they recognise creativity in their lessons. What are the signals they perceive that indicate to them that the lesson involves creativity? How do they experience and respond to this creativity in themselves or their students? The choice of methodological approach reflects this desire. PCT provides a powerful way to understand what people are thinking and how they are making decisions in a particular situation and I hope to use this to 'get under the skin' of science teachers as they reflect on creativity in their lessons.

The study will focus on science teachers in secondary schools with an emphasis on teaching students aged 11-16 in England.

P.4.3 A statement of position

The final study has thus been modified by my experiences, by reflection on the process and the products of data collection and by my growing understanding. This has been, at times, frustrating and has led to a feeling of the study being a bit like a stop-start drive through clogged city streets without the benefit of satnav. While the chapters which follow omit many of these false turnings, dead ends and reversals for brevity they were a significant part of the process. Using terminology common in discussions about creativity these were the divergent phase of the project while the data collection and analysis stages formed the convergent phase.

The chapters that tell the story of this study follow a fairly standard model. In the introduction for each chapter I sketch out the issues the chapter addresses in terms of some more specific

questions and show how these move the study onwards. In the final section in every chapter I review the material covered and summarise how this has developed my understanding.

However, despite the tortuous journey to this position my original desire to produce something that could support teachers as they seek to encourage and support creativity in their students remains. At the end of this thesis is a postscript which will explore if that wish has been granted through the work.

Chapter 1: The significance of creativity

1.1 Introduction

The adjective ‘interesting’ is almost always a contraction of the phrase ‘interesting to me’ and simply because creativity is ‘interesting to me’ this does not make it necessarily a topic worth exploring. In this chapter I consider the significance of creativity across a number of fields, not just in science education, and ask what impact it has on individuals and society as a whole. Is creativity merely of interest to those identified as ‘creatives’ or does it impact all of us? Is that impact always benign? At a time when schools, in the UK at least, are targeted almost exclusively on student and teacher performance, measured by success in public examinations, is creativity a distraction more suited to happier, less pressured times?

1.2 The value of creativity

Creativity is a concept that is as familiar in global boardrooms as in writers’ conventions or government pronouncements on education. Even the simplest Google search for the term ‘creativity’ in August 2017 produced 470 million references. The results ranged across art, music, culture and literature alongside business, politics and economics. They included suppliers keen to provide pens, pencils, paints and paper alongside a wide range of other media to allow people to display their creativity. Other items for writers, screen writers, amateur photographers and digital artists, interior decorators and anyone who might possibly claim they needed to do something creative were also available. Offers for training (e.g. how to use Photoshop, how great writers ensure believable plots etc.) and a wide range of research articles, discussions and polemics about creativity were also present. Clearly creativity was something that impinges on a wide range of people in a wide variety of ways.

The arguments for the value of creativity can be categorised into four broad areas:

- **economic**: creativity is the source of innovation and future prosperity,
- **cultural**: it is intrinsic in the stories we tell and the songs we sing,
- **personal growth**: creativity is strongly linked to personal growth,
- **educational**: creativity has repeatedly been linked with an improvement in learning for students.

1.2.1 Creativity and the economy

At the individual company level there is a lot of money to be made from creativity. Hobbycraft is only one of the many companies that sell materials to professionals and amateurs to support their creativity. The range of products is significant and many of the Hobbycraft stores are giant warehouses in out-of-town shopping centres turning over hundreds of thousands of pounds every

month. Hobbycraft Trading Ltd. had a turnover of £151.8 million from its 80 stores across the UK in 2016 (up from £141.1 million in 2015) and made a profit of £4.9 million. (Hobbycraft, 2016)

But Hobbycraft is only one company in one sector of the creative industries.

The UK government Department for Media, Culture and Sport (DCMS) includes all of the following industries within the creative sector when compiling its report about the economic value of creativity to the UK:

- Advertising and marketing.
- Architecture.
- Crafts.
- Design: product, graphic and fashion design.
- Film, TV, video, radio and photography.
- IT, software and computer services.
- Publishing.
- Museums , galleries and libraries.
- Music, performing and visual arts.

In 2009, these creative industries accounted for 2.89% of Gross Value Added (GVA) in the UK at £36.3 billion. 10.6% of all UK exports in 2009 were from the creative industries (29% of this from publishing, 25% from television and radio) while the workforce in the creative industries stood at 1.5 million people or 5.14% of the total UK workforce (DCMS, 2011).

In January 2016, DCMS published results for 2014 showing that the creative industries were worth £84.1 billion to the UK and comprised 5.2% of the economy - a rise of 8.9% since 2013. DCMS also noted that the creative industries were growing at a faster rate than the rest of the economy implying that they would become more important still. (DCMS, 2016). A projection for future value from Creative Britain (Falmouth University, 2014) predicted a GVA of £100 billion by 2018.

If the products of creativity (books, films, software) make money then creative capability must be valuable amongst the workforce. Unsurprisingly, the arguments for creativity in the workforce have been rehearsed by governments the world over. In the UK the 2010-2015 coalition government's strategy for growth was outlined in a speech by David Cameron, the then Prime Minister, in May 2010 (my emphasis).

> 'It [government support for industry] does mean supporting growing industries – aerospace, pharmaceuticals, high-value manufacturing, hi-tech engineering, low carbon technology. And all the knowledge-based businesses including *the creative industries*.' (UK Government, 2010)

President Obama, in his 2012 Budget statement, *Winning the future*, also talked about the essential role of creativity and innovation.

> 'America's future economic growth and international competitiveness depend on our capacity to innovate. We can create the jobs and industries of the future by doing

> what America does best – investing in the creativity and imagination of our people. To win the future, we must out-innovate, out-educate, and out-build the rest of the world.' (Strategy for American Innovation, executive summary)

He backed this talk with $148 billion dollars for research, mainly in the science, technology and engineering fields which he hoped would drive the US's emergence from recession, and a commitment to produce 100,000 new science, technology, engineering and mathematics (STEM) teachers in the following decade.

As President Obama's commitment to technology and engineering showed, creativity was seen as a capability needed by all businesses - even beyond the obvious 'creative industries' of the UK's DCMS.

In 2010, IBM conducted a survey of more than 1,500 Chief Executive Officers across the 60 countries and 33 industries which confirmed that creativity was the feature that CEOs thought would be most important in the coming business environment (IBM, 2012).

> 'Asked to prioritise the three most important leadership qualities in the new economic environment, creativity was the one they [the CEOs interviewed] selected more than any other choice.' (Capitalising on complexity, p24)

The People's Republic of China is also moving towards a more creative economy. In a UNESCO-sponsored Asia-Pacific Programme of Educational Innovation for Development (APEID) conference in Jakarta in 2011, Prof Wang Libing from Zhejiang University, China signalled a significant change of emphasis in the world's largest economy when he quoted from the Chinese government's 2010 plan for education and industrial development.

> 'The promotion of a creative and innovative and entrepreneurial knowledge society, moving from a 'world factory' to a knowledge-intensive, innovation-based country'. (UNESCO-APEID Jakarta 2011 Conference proceedings).

The same APEID conference also looked at entrepreneurship. Graduate unemployment is a problem in Indonesia and many of the other S. E. Asian countries. Korea sent 63% of all youngsters born between 1975 and 1984 to university (OECD, 2011) with consequent flooding of the jobs market with qualified people who found it difficult to find suitable employment. The response to this across the region has been entrepreneurship education which seeks to move young graduates from being 'job seekers' to become 'job creators'.

Creativity has also been seen as a way to regenerate disadvantaged areas in cities across the USA and Europe. In the UK, Leicester has a 'cultural quarter', including a Cultural Quarter Business Association, who claim on their website that 'our aim is to influence the economic prosperity of the area'. Leicester City Council (LCC, 2012) makes similar claims.

> 'In 1999, Leicester City Council's creative vision led to the development of Leicester's Cultural Quarter, which planned *to revitalise the once run-down district* of the St. George's area.' (my emphasis) (retrieved from website July 2012).

In the US, similar claims were made by Florida (2002) and others that the 'creative class' can drive regeneration and development. The argument runs that creatives tend to earn more money than

other workers, are attracted by potential and so are willing to move into slightly more run down areas provided that those areas offer the three benefits of 'technology, talent and tolerance' (Florida, 2002). He quoted evidence to show how factors such as the gay index (a measure he used to quantify 'tolerance') is positively linked to areas with a large number of creatives and an increase in community and financial development. Some urban regeneration activists now view creativity as a tool to drive improvements in urban environments even if they find that an increase in the money flowing into an area is not always evenly spread. Workers like Stern and Seifert (2008) still maintain creativity can improve an area but differ slightly with Florida on the emphasis between individual creatives and the creative culture of an area.

It has been claimed that creativity can make a contribution to GDP, move firms and whole countries from simple 'metal bashers' to 'knowledge and innovation-led enterprises' and even revitalise run-down areas. With such a potential prize on offer it is little surprise that the economic case for creativity in education has been made by governments and businesses across the world.

1.2.2 Creativity and culture

Culture has been defined as 'that complex whole which includes knowledge, belief, art, morals, law, custom and any other capabilities and habits acquired by man as a member of society.' (Taylor, 1974) Creativity, by definition, generates novel ideas and objects which help to build and develop a culture rather than condemning it to endlessly repeat existing practices.

Culture can also be defined more narrowly as relating to artistic work. In this sense, cultural education is seen as delivering an appreciation of, and capability in, artistic subjects. In this, more restricted, sense creativity remains vital. The UK's 2010-15 Lib-Con coalition government's view of the importance of cultural education was clearly stated in a 2013 report jointly sponsored by the Department for Education and DCMS.

> 'It is essential that all children and young people have access to a high-quality curriculum in which learning and the enjoyment of cultural subjects form an integral part of their education.' (DCMS, 2013. p37)

Even in this narrowly-defined view of culture it is easy to see that a world without the creativity of Shakespeare, Picasso, Margaret Attwood , Valmiki and Fela Kuti would be a poorer place.

1.2.3 Creativity and personal development

Creatives are almost always described in positive terms. The characteristics of creative people are discussed elsewhere (see Section 2.3.2: The creative person) but they were summed up well by Bramwell *et al* on p232 of their 2011 paper, *Creative teachers.*

> 'These creative teachers were hard-working, nonconforming, knowledgeable, intuitive, confident, flexible, and energetic.' (Bramwell *et al*, 2011. p232)

Others have spoken well of creative people describing them as having high levels of intrapersonal and interpersonal intelligences (Gardner 2001), positive values of self-direction and universalism (Dollinger, Burke and Gump, 2007; Koof *et al*, 2007) alongside flexibility and determination

(Csikszentmihalyi, 1996). Harrington (1990) suggested that creative individuals are active shapers of their environments while Runco (2004) emphasised that flexibility, an essential component of creativity, might even facilitate 'late-life adaptations and growth' (p659). He quoted a number of papers in support of creativity as an aid to personal growth and development and the suggestion that the flexibility inherent in creativity can be a contributor to optimal human functioning.

The popular press has not been slow to exploit the health-giving properties attributed to creativity. A simple search on Amazon.co.uk in June 2016 using 'creativity' as the search term produces a list of 8,585 books. Of these, 768 are described as 'Art, Architecture and Photography' while 'Science and Nature' scores 1,798. Another big group in the Amazon listings is labelled 'Health, Family and Lifestyle' and produces 3,239 hits - many of which claim to show how readers can increase their personal creativity and live happier, more fulfilled lives as a result. Creativity is clearly perceived by many to be good for you.

1.2.4 Creativity and education

Creativity is explicitly mentioned as a key outcome for many education systems. This reflects the widespread belief that creativity makes a valuable contribution to the economic and cultural health of a country alongside supporting development of the individual. These arguments for including creativity as an aim of an educational system appear strong. However, creativity is not universally regarded as important, or even positive, and section 1.2.4.2 will explore some of the negative associations of creativity in education.

1.2.4.1 Benefits of creativity

Creativity's ability to drive economic development has been described in section 1.2.1 and so it is not surprising that economies seeking the most rapid economic development are particularly concerned with creativity (Shaheen, 2010). Creativity has been suggested as a key aspect for the 'tiger economies' of China and S. E. Asia and, since this may present some cultural and social difficulties, the drive towards a more creative workforce must begin in schools.

> 'Therefore, a new Asian generation must go in the opposite direction [away from conformity], which means that they need to become creative and productive persons. As a result, education that yields creativity and productivity is essential for Asia.' (Sinlarat, 2002. p 140)

The flexibility that creativity depends upon, and promotes, allows adults to cope with the opportunities offered during times of change (Runco, 2004). To not promote creativity in the classroom would be to leave out a valuable aspect of the child's development.

> 'The flexibility of creative persons is what gives them the capacity to cope with the advances, opportunities, technologies, and changes that are part of our current day-to-day lives.' (Runco, 2004. p658)

McWilliam *et al.* (2008) made the case that science education, in particular, was in need of an input of creativity to reduce the numbers opting out of science across the world.

> ‘We argue that embedding teaching for creativity is a means of achieving a reinvigorated science curriculum and pedagogy that has potential to contribute to reversing the flight from modern science for the following reasons.’ (McWilliam *et al*. 2008. p228)

While Bramwell *et al* (2011), in their case study of creative teachers in Canada, stated simply that ‘Creative teachers are critical to successful education.’ (p232).

The arguments in favour of a more creative approach to the classroom have been rehearsed in a number of papers (Kaufman and Sternberg 2007; Runco 2004) leaving Rinkevitch (2011) to summarise the key benefits.

> Creativity not only is conducive to learning, student achievement, and cognitive development but also is a predictor of academic success (Eckhoff and Urbach 2008; Freucnd and Holling 2008; Leahy and Sweller 2008; Schacter, Thum, and Zifkin 2006). Current research also shows that creativity enhances learning by making it more meaningful than simple rote learning (Palaniappan 2008; Schacter, Thum, and Zifkin 2006). (Rinkevitch, 2011, p 219)

1.2.4.2 Costs of creativity

While the arguments for creativity as an essential component of a modern education remain strong there are other views. Creativity has been seen as an ‘optional extra’ suitable for students who were already achieving in the, allegedly more important, traditional academic areas. Michael Gove, (the UK Secretary of State for Education from 2010 to 2014 and so responsible for policy and delivery in the UK school state sector) highlighted this view when he described ‘the best schools’ in a speech to the National College for School Leadership in September 2011.

> ‘Schools that appreciate the need to foster creativity - in graphic art, in design, in music, in dance, in drama and in literature, while at the same time recognising that their pupils can only truly be creative when they’ve mastered the basics.’ (Gove, 2011)

Clearly, creativity (as defined by the ‘arts’ rather than President Obama’s wider description including technology and engineering) was seen an optional extra and only available to students who have already ‘mastered the basics’. Indeed, only students who have ‘mastered the basics’ can be truly creative. Kaufman and Sternberg (2007) pick up similar attitudes in their review of curricula and teaching.

> ‘Creativity is sometimes seen as *irrelevant* to educational practice. With an increased focus on standardized test scores, creative teachers and those who encourage creativity in the classroom often are accused of being idealists or *missing the big picture*.’ (Kaufman and Sternberg, 2007 p55).

Even those who approve of creativity in schools, have admitted that there is a cost to teaching it in terms of time (Cheng, M.Y. 2010). However, while they accept that time is needed they claim that it is essential that opportunities are made available for creativity and suggest that any time constraints are more to do with other aspects of the curriculum - not the creative work. In an open

letter to the Education Secretary published on 20th March 2013, 100 university academics explained their worries that the content load of the curriculum was crowding out creative work.

> 'We are writing to warn of the dangers posed by Michael Gove's new National Curriculum ... The proposed curriculum consists of endless lists of spellings, facts and rules. This mountain of data will not develop children's ability to think, including problem-solving, critical understanding and creativity.' (Independent newspaper, 2013)

The comments above referred specifically to the proposed English curriculum but they mirror similar comments concerning other subjects, including science. Cheng (2010) reported the same 'creativity as an extra burden' insight from a study of 75 teachers in China where lack of creativity teaching resources, poor creativity teaching skills, a low priority for creativity in school policies and the demands of a content-heavy curriculum combined to produce a sense of 'helplessness' (p127) in teachers leading to lack of progress.

Looking at science classrooms, Schmidt (2011) concluded that achievement depends on the acquisition of high-level domain specific knowledge as well as opportunities to apply that knowledge. If people who feel that creativity takes more time are correct, then this will lead to less time for the acquisition of high-level domain knowledge and so greater achievement. The link between creativity and academic achievement is also not clear. Kim and Michael (1995) found no correlation between creativity, as measured by Torrance Tests of Creative Thinking (Torrance, 1966) and academic achievement in a study of 193 Korean high school students.

The PISA results for 2012 included, for the first time, a test of problem solving alongside the more traditional tests for science, mathematics and reading. The international body, as reported in the Times Educational Supplement (TES) of June 21st 2013, is also looking at measuring the ability to deal with ambiguity and uncertainty, the ability to collaborative around problem-solving and creative tasks. The University of Melbourne (Binkley *et al*, 2012) was tasked with organising a major international effort around these skills. However, even this slight change in emphasis by PISA has not been received with universal approval. From the TES article cited above:

> 'Sheila Lawlor, director of UK thinktank Politeia, said: "Trying to measure things like creativity and so on with a huge cohort from a range of backgrounds is not a sensible task and is a waste of money. It can't be done.' (quoted in Pisa's tests could get curiouser and curiouser in TES, June 23 2013)

1.2.4.3 Creativity and disruption

Independently of worries about the extra load placed on students or teachers by creativity there are reports of teachers finding creative students challenging. More creative students are considered more disruptive than less creative ones (Scott, 1999) with some teachers regarding their willingness to ask questions as an interference in their lessons. In a study of 576 teachers in Portugal (Morais and Azevedo, 2011) the descriptions of the typical creative student were not all entirely positive. Positive characteristics like having good ideas and the generation of alternative approaches were strongly represented in the teachers' perceptions but the disconnect between

creativity and academic success was also clear and the attitudes to behaviour was more nuanced than some other factors. An intriguing experiment showed that creative students were more likely to cheat and were better able to justify their actions than less creative ones (Gino and Ariely, 2011).

1.3 Reflection

Looking back over the material covered in this chapter the argument for creativity as a significant part of business (DCMS, 2016; Obama, 2012), culture (DCMS, 2013), education (McWilliam *et al*, 2008; Bramwell *et al*, 2011) and even personal development is strong. Creativity, usually loosely defined, has been lauded by everyone from presidents and premiers to business leaders and hobbyists. It has been embedded in many curricula around the world and is increasing in importance, particularly in the high growth economies of India, S. E. Asia and China (UNESCO, 2011; Sinlarat, 2002). Clearly we all have some involvement in creativity, or the products of it, throughout our lives.

However, while creativity has been credited with everything from rescuing failing companies and even neighbourhoods (Florida, 2002), providing personal meaning and supporting optimal health (Runco, 2004) it is not regarded as entirely benign. There are costs to creativity and, in some schools in times of austerity, these costs may be high in terms of teacher loading and timetable requirements. Some also see it as a diversion from the main business of schooling (Kaufman and Sternberg, 2007; Gove, 2011) and it has become a proxy for many of the other arguments between progressive and traditionalists in education - see for example comments from authors and academics concerning the dangers of proposed changes in the UK curriculum in Section 1.2.4.2 earlier and Sheila Lawlor's comment that PISA's interest in testing creativity is 'a waste of money'. However, these criticisms all seem to depend on a very narrow understanding of creativity: essentially a view of creativity as an optional, artistic activity that makes minimal contribution to thinking and none to science. The working definition of creativity in science education (See Preface 4.1) specifically identifies that creativity must have a value in terms of 'engaging learners with, or developing, scientific domain knowledge and practices'. This means that the creativity this study is seeking to explore cannot be simply an artistic 'optional extra'.

In the next chapter I explore the development of creativity as a concept and place this in context of current research and look in particular at creativity in science education as seen through the global research literature.

Chapter 2: The concept of creativity

2.1 Introduction

In Chapter 1, I established the significance of creativity, defined as the production of novel ideas, approaches or objects that serve some purpose or have some value, in terms of its economic, cultural, personal and educational effects and revealed the considerable interest in it across government, business and individuals. However, attitudes to the desirability of creativity as an explicit goal for education are mixed. This is created, in part, by a difference in the understanding of creativity: is it an essential domain-agnostic capability (e.g. generating an idea) that is at home in science and engineering as it is in music and art or is it a time-limited activity (e.g. painting a picture) that is specifically artistic and mainly needed for recreation after the important academic subjects have been mastered?

To attempt to address this issue I look at the notion of creativity as it has developed over historical time and attempt to clarify my original presumptive definition (See Section P.4.1: A working definition of creativity in science education) in the light of the research literature. I will also use the historical approach to identify broad trends in the understanding of creativity in an attempt to see not merely where we are but where we are likely to progress in our understanding in the next few years. Given that creativity is now an extremely active area of research I review the approaches used to identify any strategies that would be useful in potential data-gathering with teachers. Finally, in Section 2.4, I look at creativity in science education: what does the existing research literature say about the nature of creativity in science lessons? Answering this question should help to clarify the environment in which the study operated in terms of existing knowledge and reveal any potentially significant gaps.

2.2 The concept of creativity

2.2.1 Early ideas about creativity

Creativity has been detectable as a feature of humanity from earliest times as represented by cave paintings (e.g. Lascaux caves) from thousands of years ago and consciously-fashioned stone tools from even earlier. Despite this, creativity has remained outside the realm of serious study for the vast majority of human history being seen as a ‘gift from the gods’. To create something out of nothing was thought to be an exclusively divine capability so people who appeared to be creative must somehow be in receipt of insights or guidance from outside.

As well as this notion of an external muse the idea that creativity was even a sort of madness was common. As Socrates explained in his dialogue with Phaedrus.

> ‘There is also a third kind of madness, which is possession by the Muses, enters into a delicate and virgin soul, and there inspiring frenzy, awakens lyric . But he, who, not being inspired and having no touch of madness in his soul, comes to the door and thinks he will get into the temple by the help of art - he, I say, and his poetry are not

admitted; the sane man is nowhere at all when he enters into rivalry with the madman.' (Dialogues of Plato)

This mystical, and even shamanistic, approach to creativity did not begin to fade until the nineteenth century and even today shadows of it persist in some turns of phrase ('the muse was upon me …', 'I was inspired…') or romantic notions of creativity although a number of published authors have somewhat different, more prosaic, views of their personal muse. The Australian author, Kerry Greenwood, who has produced over 20 novels, talks of her muse less as a source of divine inspiration and more as a demanding, all too human, taskmaster.

'If I ever saw my muse she would be an old woman with a tight bun and spectacles poking me in the middle of the back and growling, "Wake up and write the book!".'

2.2.2 Historical ideas about creativity

The beginnings of the switch from an external to an internal source for creativity began in the West with the Victorians. Sir Francis Galton (1822-1911), a cousin of Darwin, maintained that human intellect was genetically controlled. To support this idea he gathered data about the sons of eminent fathers, specifically fellows of the Royal Society of London, looking for generational transfer of genius. Bundled into his notion of genius was what a modern reader would refer to as 'creativity'. By studying its inheritance, Galton was accepting that creativity was a part of intelligence and not a gift from a benevolent deity. Accepting that he looked only at sons, that he promoted the notion of eugenics and that he did not use the term 'creativity' he did manage to decouple the notion of creativity from the mystical, god-given ideas of previous thinkers (Sternberg, 1999).

Once creativity had joined other aspects of intelligence as a function of human beings the measuring could begin. As Spearman and Binet measured intelligence, so Terman measured genius - genius was often the synonym for creativity at that time (Sternberg, 1999). Underlying much of this work was the assumption that these capacities (intelligence and creativity) were inherited, spread throughout the population as with any other genetic trait and could, eventually, be measured on a single scale. However, since creativity was considered the inevitable outflow of high intellectual ability, much of Terman's work was concerned with eminent men and high achievers. Terman, in his five volume *Genetic Studies of Genius*, (1925, 1926, 1930, 1947, 1954) emphasised this focus on the 'great and good' even in his choice of title. Cox (1926) used biographical, autobiographical and sociocultural information about her chosen subjects to build up very rich pictures and generate values for IQ for individuals who were long dead. She found that creativity was positively correlated with intelligence although the prevalence of male, Western members of her data set does raise some cultural and political questions.

However, by the middle of the twentieth century creativity, often re-badged simply as genius, was considered to be largely genetically-controlled and exhibited to a significant measure by only a small number of eminent individuals who changed the world through their actions. Psychologists studying creativity might have found themselves tempted to replay Lord Kelvin's alleged remark to

the British Association for the Advancement of Science in 1900, just five years before Einstein published the Theory of Special Relativity, 'There is nothing new to be discovered in physics now. All that remains is more and more precise measurement' by saying that creativity was not a topic worth studying.

2.2.3 Modern ideas about creativity

2.2.3.1 J. P. Guilford

Guilford (1950) re-ignited the study of creativity with his 1950 inaugural address as president of the American Psychometric Association. He maintained that humanity was moving into a new world where creativity was a key requirement for our continued survival and lamented the apparent lack of interest in creativity making a plea for increased research activity. He accepted that there were real reasons to explain what he called the 'neglect of the study of creativity' and identified the idea that creativity was special or rare as a problem. He quoted, and questioned, the suggestion from Giddings (1907) that 'of all the people who have lived in historical times only about two in a million have become really distinguished'. To Guilford, creativity was much more widely spread and, counterintuitively, both much more important and much less special than Giddings might have suggested.

Guilford did not just encourage others to explore creativity, he also worked extensively in the field himself and coined the terms 'divergent' and 'convergent' thinking. Divergent thinking leads to multiple possible solutions to a problem (with a range of degrees of potential success). It sees possibilities and is the thinking 'outside of the box' favoured by modern day creativity gurus. Convergent thinking is the opposite focussing down on the single or optimum solution to a problem. It is tempting to believe that creative thinkers are divergent while others are convergent. In fact, creative thinkers appear to be able to think divergently when appropriate and convergently when required. Although high intelligence (as measured by IQ) tends to be associated with creativity some people with high IQs do not always appear to have high creative potential as defined by standard tests (Gajda *et al*, 2017; Neubauer *et al,* 2013). To be creative you need to be able to function in both realms (divergent and convergent) whereas to be defined as intelligent you may get away with skills in just one area as many of the tests used to recognise and quantify intelligence (IQ tests, school examinations) are heavily weighted in favour of convergent thinking usually requiring single, correct answers.

2.2.3.2 Novelty and value

Although creativity is a flexible concept and not easily defined this has not prevented many from attempting the task and as long ago as 1963 there were 70 definitions in the literature. Sternberg (1999) summarised the core of many of these by defining creativity as a two-factor combination.

> '<creativity is> the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task constraints).' (Sternberg, 1999 p 3).

Other writers have gone beyond the two-factor model. Boden (2007) suggested that creative ideas had to be novel, valuable and surprising. Cropley (2001) extended the ideas of novelty and value (which he called effectiveness) by adding a third component: 'ethicality'. The concept of ethicality revolves around the use of creativity for positive, productive purposes rather than simply licensing destructive behaviour. Amabile (1996) agreed that creative work must produce something that is novel, useful and appropriate but further required that the mechanism that produced these outputs was heuristic rather than algorithmic. These additional criteria for creativity are shown in Figure 1.

Simonton (2012) offered a quantitative definition of creativity based on the criteria used by the United States Patent Office to decide if an invention is worthy of patent protection. These criteria require an invention to be new (N), useful which he labelled as utility (U) and non-obvious which he called surprising (S). Creativity (C) is then defined as the product of these three factors where each factor can vary from 0 to 1.

$C = N \times U \times S$

Figure 2.1 summarises these additions to the standard definition of creativity showing how all include the common core of 'novelty' and 'value'.

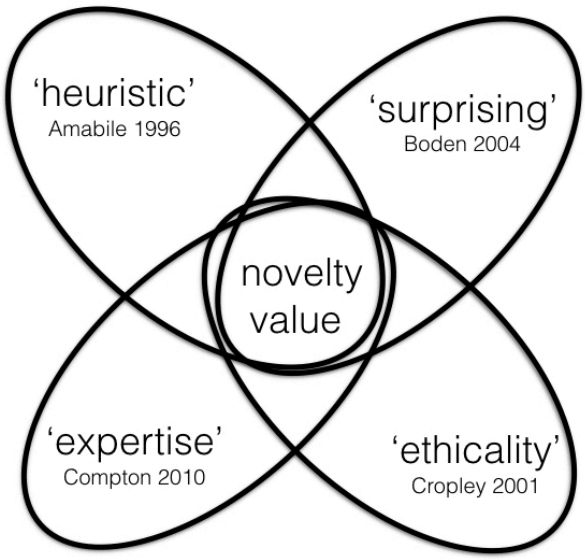

Figure 2.1: Characteristics of creativity

2.2.3.3 The scale of creativity

The idea that not all creativity is equal is easy to appreciate. Little-c covers everyday creativity (e.g. choosing colours to decorate a bedroom, making a meal from ingredients found in the fridge, planning a suburban garden) whereas Big-C is genius-level creativity (the theory of relativity, Picasso's Guernica, Star Wars). This distinction between 'little-c and Big-C' creativity, (Guilford, 1950) has been a feature of much of the discussion since the 1950's. It offered a convenient way to bridge work on 'eminent creatives' and research based in education or business who were working with younger people or on less obviously ground-breaking or high-brow activity.

Beghetto and Kaufman (2007, 2009) offered a more nuanced unpacking of creativity in their Four C Model. They defined mini-c as 'novel and personally meaningful interpretation of experiences, actions and events'. Mini-c was a personal 'making sense of the world' by integrating sensory data with previous experiences and understanding to create personally valid meaning. There may have been a simple product, for example a child's painting, but this was not necessary. Mini-c provided a good way to discuss the earliest stirrings of creative capability and so remains of considerable interest to educationalists. Little-c covered activity that was instantly recognised as 'creative' in that there was a product, of varying degrees of sophistication, with limited and local impact. This is the area where most of us will be creative and where a great deal of the research into 'how to be creative' is focussed. This is the zone of brainstorming, oblique strategies, 10-tips-for-creativity websites and so on.

The model described a new flavour creativity which Beghetto and Kaufman called professional-C or Pro-C. Pro-C creatives will have invested effort and time to develop their skills so that they are regarded as having a professional level of competence. These are the professional chefs, respected journalists, commercial musicians and living artists that could sustain an exhibition in any of the large cities across the globe. This is clearly a step up from little-c creativity but does not yet stray into Big-C creativity which is reserved for the figures who have, or will have after their day, a global impact. In fact, progression from Pro-C to Big-C might require some time after the original creator's death to see if the products of their work merit Big-C status.

Figure 2.2, reproduced from Beghetto and Kaufman's 2009 paper, shows how their four different creativities can develop. So, mini-c can be converted into Pro-c by a formal apprenticeship, perhaps in a machine shop or a kitchen. Alternatively mini-c might develop into little-c through what they call 'tinkering'. This is a development that is much more under the control of the individual given that it is not driven by the demands of a course and may seem like playing from the outside. Hobbyist painters, writers and craftspeople would fall comfortably into this group. Little-c, in turn, can develop into Pro-C as the hobbyist finds more and more people willing to pay for the paintings / meals / inventions that they produce. Yet many people who would fit into the little-c category have no desire to do this and paint / write / construct for their own satisfaction and pleasure. Kaufmann and Beghetto say these people are engaging in reflection - their creative activity reflects back into their own lives and enriches them in some way independent of others' approval.

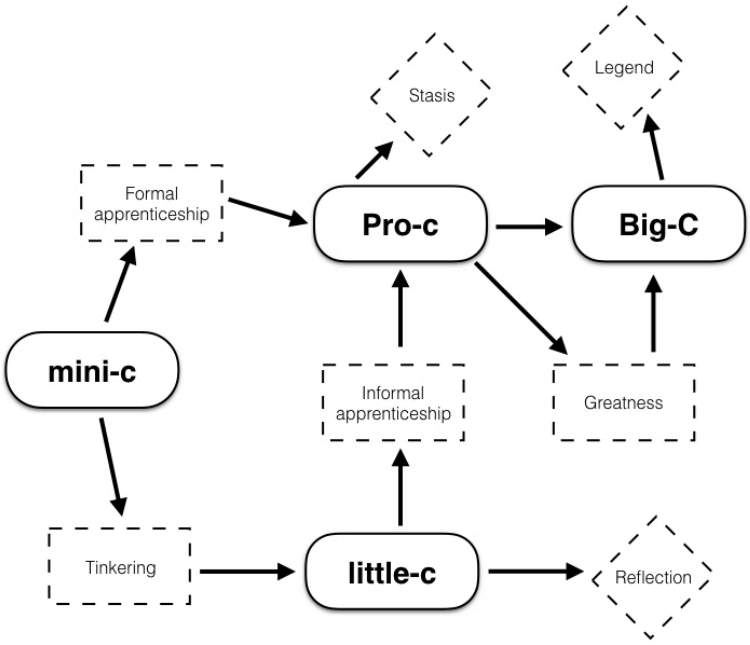

Figure 2.2: The Beghetto Kaufman 4-C model of creativity

Compton (2010) reviewed a range of definitions of creativity and produced a diagram (see Figure 2.3) which both summarised his ideas and linked to a number of previous attempts. He did this because he claimed that the ‘confusion about definitions (of creativity) is one of the main threats to the place of creativity (in the English National Curriculum)’ (p26). He justified his worry to himself when he stated that many of the general public associated creativity with misbehaviour (‘doing whatever you like or behaving in an undisciplined way’ p27) and that even in schools many teachers could not distinguish between creative behaviour and misbehaviour so that creative pupils were often unpopular with teachers. If this was not bad enough, the other key association of creativity appeared to be with madness citing Van Gogh as an example of the archetypal ‘mad genius’. To tackle this problem, Compton suggested a clear definition of creativity was required and he produced his pyramid to summarise previous work, catalogue the components of creativity and show how these worked together to develop creativity. His diagram showed layers of activities that supported development of a healthy creative capability culminating in layer 4 with the highest form of creative endeavour defined as ‘making something new and valuable to society as a whole, working at the pinnacle of the field in skills, knowledge, understanding and vision’. Compton’s contribution to the definition of creativity beyond ‘novelty’ and ‘value’ was ‘scale’ (society as a whole) and ‘expertise’ (the pinnacle of the field)

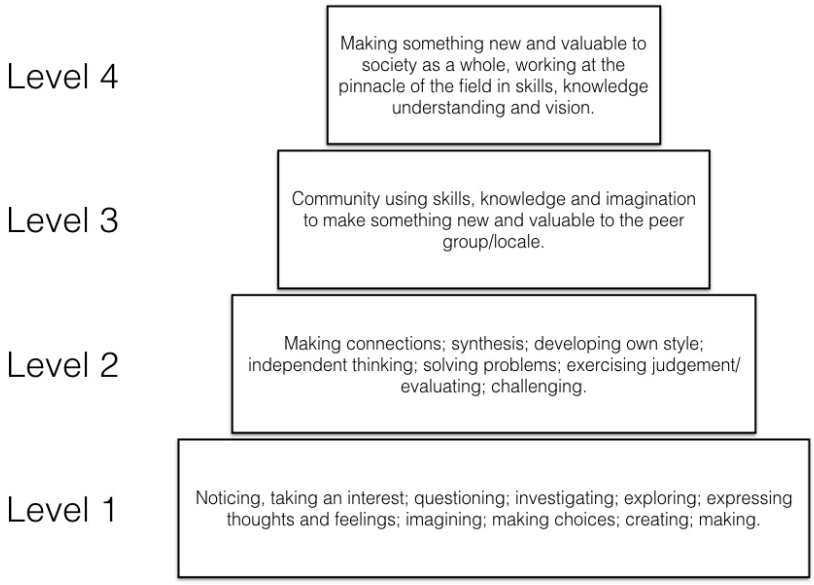

Figure 2.3: Compton's creativity pyramid

2.2.3.4 Field and domain

Csikszentmihalyi (1996) explored the ideas of novelty and value and the involvement of the wider environment in recognising creativity. He identified a number of factors in the truly creative (i.e. novel and valuable) idea. It must be novel but draw on ideas, Csikszentmihalyi called these memes, that were current within the domain into which the idea was to be launched. A domain could be a field of scientific research, a style of visual arts or music or any other discipline with broadly-agreed borders. Domains are inhabited by a number of capable judges, called the field, who can then assess the value of the idea. Only when it has been accepted by the field and built into the domain's paradigm is it considered truly creative. Novelty and value are thus defined by the relevant domain and field. Since the field acts as a gatekeeper to the recognition or validation of creativity there are dangers that it can misjudge developments, (e.g. Wegener's views on continental drift were dismissed as outlandish and Van Gogh' paintings were rejected as ridiculous by the apparently informed judges of their day). While the field can sometimes fail to recognise creative genius the insistence on the use of memes from a domain and the approval of the field does prevent the merely bizarre qualifying as creative.

Sternberg (2012) invoked a similar idea when describing the 'investment model' of creativity which suggested that creative people were good at finding ideas in their area of work (the memes in Csikszentmihalyi's domains) that could be developed.

> 'Creative people are ones who are willing and able to metaphorically buy low and sell high in the realm of ideas. Buying low means pursuing ideas that are unknown or out of favour, but that have growth potential. Often, when these ideas are first presented, they encounter resistance. The creative individual persists in the face of this resistance, and eventually sells high, moving on to the next new, or unpopular, idea.' (p5)

The significance of creative thinkers operating within a domain and, potentially with other workers, led to an interest in collaborative creativity. Some of the skills needed for creativity identified by McWilliam (2007, 2008, 2009), although not directly part of creativity, are essential for it to flourish in the modern world. Many of these skills are linked to communication and networking including finding these memes or low value ideas and having the ability to sell their developments at a later date into a potentially hostile market.

2.2.3.5 Creativity as 'art'

Creativity has sometimes been regarded as more common in the arts in comparison to science and technology which were seen as more formulaic. Using interviews and written questionnaires, Gluck *et al* (2010) looked at the perception of creativity in two artistic professions: 'free' artists, exemplified by artists working without briefs and 'constrained' artists working as graphic artists in businesses. Her findings showed that 'free' creatives tended to identify originality of solutions and certain personal characteristics of the practitioner (a 'creative personality') as the key features of a definition of creativity. Constrained artists emphasised the functioning of the product and the

sophistication of its presentation more strongly (a ‘creative product’). These differences illustrated the range of tones available within the definition but the summary remained clear: novelty (originality) and value (functionality) are the key issues.

The National Advisory Committee on Creative and Cultural Education (NACCE), which published *All our futures: Creativity, Culture and Education* in 1999, opted for a decidedly arts and craft flavour when it defined creativity.

> ‘Creativity is imaginative activity fashioned so as to produce outcomes that are both original and of value.’ (p30)

The report goes on to illustrate this with largely art-based examples. Five years later in 2004 the *Futurelab Creativity and Collaboration Handbook* stretched the scope slightly further.

> ‘Creativity is no longer regarded as a discrete skill required for art, drama or music, but rather it is seen as central to children’s abilities to work imaginatively and with a purpose, to judge the value of their own contributions and those of others, and to fashion critical responses to problems *across all subjects in the curriculum*.’ (my emphasis).’ (p2)

This laudable perception was somewhat undermined by the content of the remainder of the handbook which remained relentlessly drama and media-focussed.

It is notable that the ‘creative industries’, as defined by the UK Department of Media, Culture and Sport includes, amongst others, advertising and marketing, crafts, product design, graphics, fashion, film and publishing but not science, technology or engineering. (See Section 1.2.1). This attitude probably comes from the fact that it is relatively easy to recognise a painting, a novel, a piece of music or sculpture as a creative product. The notion that an incremental increase in our understanding of the mechanism of insulin action or clarification of the significance of decomposer organisms in a swamp ecosystem are also creative products has, traditionally, been more difficult to accept.

2.2.3.6 Creativity as an essentially contested concept

The notion of ‘essentially contested concepts’ (Gallie, 1956) may provide a useful way forward to allow exploration of creativity. Gallie explained that an essentially contested concept is one which has a clear meaning to a particular group of thinkers, who understand it in terms of the use they make of it, but which differs from, equally valid, meanings used by other people. He cited statements such as ‘this picture is a work of art’ as indicative of a contested concept (art) where different people have different views of what constitutes ‘art’. In comparison, the statement ‘this painting is painted in oils’ is uncontestable and easily verified because there is no disagreement about the notion of oils with regard to paint. To qualify as essentially contested a concept must be:

- Appraisive - it accredits an achievement of some value.
- Demanding - the achievement must require some skill or knowledge.

- Complex - the components of the concept must be rigorously defined and clearly consistent within the wider concept.
- Open - the concept can be modified in the light of new attitudes, insights and evidence.
- Partisan - users of the concept have a particular, partisan view of it and defend this against others.

Creativity meets these criteria in that it signifies something of value, it requires effort, has an internal structure, has been modified many times during its history and is used by people who adopt a particular view to exclude, or include, certain senses of the word. If creativity is essentially contested then a simple definition may be both unobtainable and potentially not very useful.

The slightly different descriptions of creativity described in this section, for example Kaufmann and Beghetto's 4C model or Sternberg investment model are best seen as complementary offering insights into different aspects of creativity rather than alternatives to choose between.

2.2.3.7 Trends in the understanding of creativity

In 2018, the definition of creativity remains open to discussion. It involves novelty and value (although the relative importance of these may vary in different disciplines) and can be extended by other factors although there is considerably less agreement about the number and nature of these. While creativity is probably helpfully regarded as an essentially contested concept there are trends in the understanding of many aspects of creativity and these are illustrated in Table 2.4.

Table 2.4: Trends in the understanding of creativity

	From...	To...
Source	External, supplied by a god or other mystical source. Creativity was a gift, or a curse, and was not amenable to human study or improvement.	A mixture of internal (genetic) and environmental with the option that the environment can be altered to increase human creativity.
Scope	Largely artistic, related to production of creative artefacts (e.g. sculptures, paintings, literature) or events (e.g. plays, music).	Spread more widely and including technical (e.g. scientific theories) and wider cultural products (e.g. political constitutions).
Prevalence	Rare, only the largest impacts qualified as 'true creativity'. It was the province of 'great men' and 'eminent creatives'.	A more widely-spread commodity with an assumed normal distribution although some of the lower levels of creativity might appear trivial and local.
Scale	A game-changer, but needed in small amounts as the impact is often global.	A range of capabilities differing both qualitatively and quantitatively, e.g. little-c and Big-C creativity, the Four C model or Compton's Pyramid model.

	From...	To...
Nature	A single, simple characteristic often equated to genius.	A complex set of different capabilities working together (e.g. convergent and divergent thinking, associated creativity-supporting skills).
The 'creative entity'	The person - often in isolation and seen as 'different'.	The system - consisting of both the individual and their intellectual and social environment.

2.2.3.8 Creativity in science education

The Preface provided a definition of creativity in science education and a brief amplification.

> 'Creativity in science education involves the production of novel ideas, approaches or objects that serve some purpose or have some value in the context of engaging learners with, or developing, scientific domain knowledge and practices.' (Preface, p16)

How does this presumptive definition fit within current thinking and the trends previously identified. Firstly, nothing in this definition contradicts other definitions detailed in this section having, as it does, a clear focus on novelty and value. That it clarifies the meaning of value in terms of 'engaging with' (i.e encouraging students to study science) or 'developing' (i.e. increasing the sophistication) of scientific domain knowledge and practices is arguably helpful in providing a clear science education focus. Other than this clarification, the definition offers no guidance on the mechanism of creativity in science education and does not provide a list of component skills or strategies. This is not unintentional reflecting the brevity of most of the other definitions of creativity available. Section 2.4 will explore these issues in more detail.

2.3 Creativity research

Creativity research is an extremely active branch of research because of the value of creativity (see Section 1.2 The value of creativity). Section 2.3 of this chapter looks at four broad approaches adopted by creativity researchers.

2.3.1 The 4-P approach to the study of creativity

Guilford's claim that 'the neglect of this subject [creativity] is appalling' in his 1950 presidential lecture to the American Psychological association (Guilford, 1950) is no longer true. Creativity research is now a very active field and a Google Scholar search for 'creativity in science education' produced 1.9 million hits in August 2017. There are also a significant number of journals with international readerships devoted specifically to the study of creativity, for example

the *Creativity Research Journal*, *Thinking Skills and Creativity* and *Creativity and Innovation Management*.

The current approaches to the study of creativity have been usefully organised around four approaches, often called the 4-P approach, identified as Person, Process, Product and environmental Press (Rhodes, 1961).

- **Person**: studies of aspects of the creative person including their personality, intellect, temperament, attitudes and behaviours.
- **Process**: studies of the process that is characterised as creative including issues around motivation, perception, learning and thinking.
- **Product**: studies looking at creative products and their attributes.
- **Press**: studies of the environment in which creativity occurs and the fact of the environmental press on individuals and groups.

This classification does not imply that one of these four approaches is better than any other or that one will provide a complete description of creativity. Indeed, they inevitably overlap but provide a useful way to explore current studies into creativity and the issues addressed.

2.3.2 The creative person

2.3.2.1 Searching for characteristics of creative people

Psychologists who predominantly approach the study of creativity through observations of the creative person use a variety of ways to assess a person's personality, behaviour, style, attitude, interests and values and try to identify particular features that are common in people who are regarded as creative by some other measure (e.g. acclamation by peers). The tests can be self-administered or completed on behalf of a person by another (e.g. teachers might complete the test on behalf of their students).

A summary of the characteristics that creative individuals are more likely to exhibit, as revealed by these tests, are given in Table 2.5 (Abdulla and Cramond, 2017). Unfortunately, the list is encyclopaedic and probably contains too many characteristics to be very useful. This may be because the range of tests are looking for different characteristics.

Craft (2005) quoted Brolin's earlier 1992 summary of the research into characteristics of creative individuals and offered this list:

> 'creative people tend to show strong motivation, endurance, intellectual curiosity, deep commitment, independence in thought and action, a strong desire for self-realisation, a strong sense of self and self-confidence, an openness to impressions from within and without, an attraction to complexity and obscurity, a high sensitivity with a high capacity for emotional involvement in their investigations.' (Craft, 2006 p6)

Table 2.5: Characteristics that distinguish creative individuals

Active	Clever	Impulsive	Motivated
Adaptable	Curious	Independent	Original
Adventurous	Daring	Individualistic	Progressive
Aesthetic	Dreamy	Industrious	Questioning
Alert	Energetic	Innovative	Resourceful
Ambitious	Enterprising	Inquisitive	Risk-taking
Autonomous	Enthusiastic	Intrinsic	Self-confident
Artistic	Flexible	Intelligent	Humorous
Capable	Imaginative	Inventive	Unorthodox

Horng *et al*. (2005) provided yet another list of the characteristics of creative teachers.

> 'Many studies have evidenced the influences of personalities and developments of creativity. The common personality traits of subjects are: self-confidence, openness to experience, fantasy-oriented, imagination, emotional sensitive, drive and ambition, norm doubting (questioning established norms), nonconformity, attraction to complexity, aesthetic orientation, flexibility of thoughts and risk taking.' (p 352),

Notably, lists of characteristics of creative people always seem to be long and usually positive. However, creative people are not always viewed positively by the people around them and may have some negative characteristics as well. (See Section 1.2.3.4 Creativity and disruption).

2.3.2.2 Mihalyi Csikszentmihalyi

Mihalyi Csikszentmihalyi (1996), working with his postgraduate students, interviewed a wide range of eminent individuals to look for common factors in creative individuals and their experiences. Using many hundreds of these interviews he was able to identify flexibility of thought as the key factor. Developing this further he described creatives as people who were able to range across a spectrum of behaviours. A creative person was not characterised by a single, specific trait but by an ability to adopt a behaviour, or its apparent opposite, as appropriate. For example, creative individuals can demonstrate enormous physical energy and activity but are able to be quiet when at rest. They are introverted at times but can behave as enthusiastic extroverts. Similarly, they range thoughtfully across mastery of their field and yet ask apparently naive and innocent questions or move forward in ways their wiser colleagues may ignore. Csikszentmihalyi identified 10 spectra that were relevant in discussion of creative personalities.

- Physically energetic - but comfortable at rest.
- Smart but naive.
- Responsible but irresponsible.
- Imaginative but rooted in reality.
- Introverted extroverts.

- Humble but still proud of, and confident in, their own ideas.
- Resistant to masculine/feminine gender stereotyping.
- Sensitive to the importance of rules - and the value of breaking them when necessary.
- Passionate about work and recognition but disinterested and objective.
- Sensitive to the pain of failed ventures but also able to fully participate in the joy of creative work.

In summary, while many characteristics of creative people have been identified over years it remains difficult to claim that a single one is a clear predictor of creative ability. Packages of characteristics, not all of them regarded universally as positive, have been proposed as indicative of potential for creative ability. Despite these complications, the study of the creative personality remains an active area of research.

2.3.3 The creative process

If psychologists who focussed on the study of the creative *person* were looking for a characteristic or set of characteristics that marked out this person as creative, psychologists whose main interest in the *process* of creativity were looking for the cognitive procedures that generated a creative output.

2.3.3.1 Creativity and intelligence

For many years creativity was not considered separate from intelligence (see Section 2.2.2: Historical ideas about creativity) with the assumption that intelligent people would also be creative. Creativity was seen as an inevitable outflow of high ability. One of the earliest psychologists to study intelligence and its measurement, Spearman, is quoted in *Creativity* Second Edition (Runco ed. 2014) as stating:

> 'That which is usually attributed to such special imaginative or inventive operation can be simply resolved into a correlate eduction combined with mere reproduction. From this analytic standpoint, then, we must predict that all creative power—whether or not it be dubbed imagination—will at any rate involve g.' (p 187).

Spearman was saying that all imagination, all creativity, is simply an outflow of cognitive processes forming part of g (his notion of general intelligence). While studies of creativity and intelligence have shown a correlation between the two (Getzels and Jackson, 1962; Gajda *et al*, 2017; Neubauer *et al* 2013) this correlation is only valid up to a certain levels of intelligence (Wallach and Kogan, 1965). Below a certain level of intelligence, as measured by IQ tests, creative potential increased with IQ but above a threshold level the relationship broke down. Threshold theory claimed that this was because a certain cognitive facility is required to engage in the creative process but that above a threshold other factors come into play. So, it is possible to have a high intelligence but, in the absence of some specifically creative functionality, be relatively uncreative. This creative ability may be linked to the ability to engage in divergent thinking. More recent analyses of Wallach and Kogan's original data (Silvia, 2008) using modern statistical techniques have shown that the correlation between intelligence and creativity may be slightly

stronger than proposed in the original paper and that this may be due to other factors (e.g. working memory span) that are also related to a measure of intelligence.

2.3.3.2 Divergent and convergent thinking

Guilford introduced the terms ‘convergent’ and ‘divergent’ thinking to distinguish between two ways to approach a problem (Guilford, 1957). Problems which stimulate convergent thinking tend to have single, known answers (the thinking converges on the single solution) whereas problems requiring divergent thinking skills typically have multiple solutions and sometimes no known solution at all. In divergent thinking there is no single ‘answer’ to converge onto so thinking diverges to all sorts of possible solutions. Tests of divergent thinking ability have been used to develop tests for creative potential, the most famous of these is probably the Torrance Tests of Creative Thinking (TTCT) (Torrance, 1966) since divergent thinking has been positively correlated with later creative achievement. See Section 2.3.4.1 for more details about TTCT.

The next section describes some of the theories concerning creative cognition. There are many. However, they all share two common features: a mechanism to produce new ideas and some way to sort the useful and productive ones from the rest. They reflect Guilford’s distinction between divergent and convergent thinking in that they first must produce a variety of options, possibly unconsciously, (divergent thinking) and then apply some criteria, again possibly unconsciously, to select the most appropriate (convergent thinking).

2.3.3.3 Associative models of the creative process

Associative theories (Mednick, 1962) have suggested that creativity depends on existing ideas combining together in some way to produce novel ideas that are somehow screened with the most potentially valuable being developed further. Simonton (2003) described Poincare’s earlier account of discovery to illustrate the idea.

> ‘In describing one discovery episode, he observed, “Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination” (p. 387). Poincare´(1921) compared these colliding images to “the hooked atoms of Epicurus” that jiggle and bump “like the molecules of gas in the kinematic theory of gases” so that “their mutual impacts may produce new combinations”’ (p393).

This seems to describe a process analogous to the kinetic behaviour of gases with ideas acting as particles. But the ‘atoms’ mentioned are not random - they are ideas relevant to the topic in question, again Simonton quotes Poincare.

> ‘The mobilized atoms are ... not any atoms whatsoever; they are those from which we might reasonably expect the desired solution’ (p389).

The initial ideas come both from an individual’s study of a knowledge domain and other, apparently more random, inputs. Another example from Poincare’s experience makes this clear.

> ‘I turned my attention to the study of some arithmetical questions apparently without much success and without a suspicion of any connection with my preceding

> researches. Disgusted with my failure, I went to spend a few days at the seaside, and thought of something else. One morning, walking on the bluff, the idea came to me ... that the arithmetic transformations of indeterminate ternary quadratic forms were identical with those of non-Euclidean geometry' (p388)

So, the creative process involved ideas (carefully garnered from previous study and, potentially, lucky happenstance) combining together, in sometimes unexpected ways, to produce new ideas and insights - the moment of combination corresponds to the 'creative leap'. Insights that have utility are presumably rescued from Poincare's 'crowd' and emphasised in a process analogous to convergent thinking. Note that while the curation of ideas and experiences to stimulate the initial idea 'crowds' is intentional, the novel 'combinations' that these 'crowds' produce can be apparently random or unpredictable. Simonton (2003) used this insight of initial careful selection and apparently random assortment to describe creative ideation as a 'constrained stochastic process' (p476).

2.3.3.4 Staged models of the creative process

Staged models of creativity describe creative thinking in terms of a series of steps or stages. Staged models have a long history including Wallas (1926) who talked of four stages: preparation, incubation, illumination and verification. Preparation concerns recognising and finding an issue or problem (and possibly bringing some relevant ideas and approaches to mind) while incubation is the stage when no work is apparently occurring but some activity is taking place below conscious awareness. Some creative people talk of 'mulling it over' and can engage in activities that are apparently nothing to do with the creative process, e.g. Einstein played his violin or went boating, Steve Jobs used to go for a walk. Illumination is the next stage, perhaps in a sudden flash, when an insight arrives - sometimes referred to as the 'a-ha!' or 'lightbulb' moment. Verification is equivalent to the judgement in the associative theory where a particular solution or insight is seen as valuable and appropriate. Staged models of creative cognition often veer towards the notion that creativity is a complex collection of, presently unknown, logical cognitive processes. The public performance (creative insight) may appear magical but behind the scenes much more pedestrian stage hands (cognitive processes) are working logically to create the 'a-ha' finale. These background processes may include restructuring of perceptions, a search for patterns, reviewing against experiences and intuition alongside other unspecified unconscious capabilities (Runco, 2014).

2.3.3.5 Component models of the creative process

Staged models rely on a sequence of stages to explain the creative process. Component-based models instead view creativity as the interplay between a number of different components. If staged models require 'A to B to C to D' component models only require that A,B,C and D all be present at the same time.

Amabile in her study of creativity in business environments (1989) suggested that the components are task motivation, domain-relevant skills and creativity-relevant processes (internal factors will include divergent thinking skills, external factors might include supervisory and work group support). Sternberg and Lubart (1996) suggested creativity depends on the right combination of intelligence, knowledge, cognitive style, motivation, personality and environmental context. Other psychologists have proposed other collections of components with Runco and Chad (1995) suggesting a tiered component model (shown in Figure 2.6) with the lower tier containing skills and the upper containing knowledge and motivational aspects.

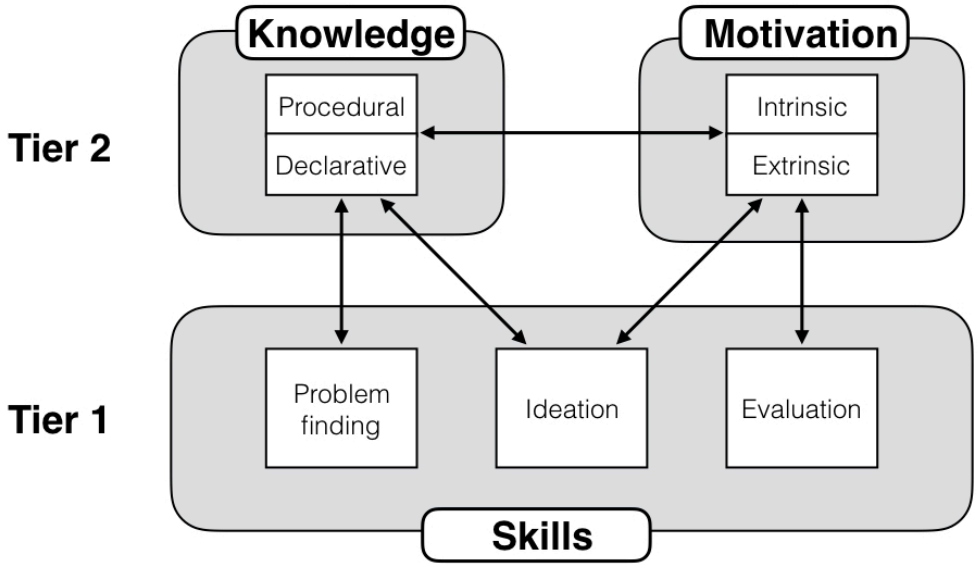

Figure 2.6: Two-tier model of creative thinking

2.3.4 The creative product

The study of creativity through the characteristics of its products is potentially problematic. A product of creativity is something that has been produced by a process previously defined as creative - it is therefore difficult to derive insight into creativity from products because the specific definition of creativity used is the gatekeeper for the class of objects described as creative. If creativity must be surprising (Boden, 2004) or ethical (Cropley, 2011) then only surprising or ethical products can be used to study it and the logic becomes self-referential. Even the core components of the creativity definition, novelty and value, are open to discussion and do not make convenient assessment criteria. Novel to who? In what context? And how novel - a minor change or a complete breakthrough theory? Similarly, value splits into many sub-questions and clarifications. Valued by whom? What value does a piece of art have? Are only problems with a potentially valuable solution amenable to creativity?

Despite these problems in the assessment of creativity through products it remains a common approach as Long (2014) reported:

> 'According to a recent review of publications in five prestigious creativity journals (Long, 2014a), about one fourth of the quantitative studies required participants to engage in creative problem solving and come up with solutions or products, which were then assessed by a panel of judges.' (p183)

The sections which follow describe some of the more common approaches where products can be any externally visible manifestation (e.g. a piece of artwork, a political philosophy, a new scientific theory or a set of answers to a series of questions in a creativity test).

2.3.4.1 Torrance Tests of Creative Thinking (TTCT)

The Torrance Tests of Creative Thinking (TTCT) (Torrance, 1966) uses divergent thinking as a correlate for creative potential. The system seeks to measure a person's facility with divergent thinking strategies by scoring their test responses (the products generated) against four criteria:

- **fluency**: the number of interpretable, meaningful and relevant responses to a stimulus,
- **flexibility**: the variety of categories of relevant responses,
- **originality**: the proportion of unexpected, unusual, unique or statistically rare responses, and
- **elaboration**: the degree of development of the suggestions with pertinent details.

The final result consists of an amalgam of these scores. In 1990, Torrance added two more scores for what he called 'creative strengths'. These were norm-referenced and broadly cover the degree of sophistication of the proposed solutions. Torrance used his tests to identify not creativity as such but creative potential and backed his research with longitudinal studies of school students to investigate how well his tests predicted future creative eminence. His data were later re-evaluated by other workers. Wallach (1976) maintained that the value of the tests was low predicting under 50% of the variation in creativity amongst the sample while a later review by Plucker (2010) using more sophisticated statistical models was more supportive.

> ‘Indeed, the results, specifically the strong predictive power of TTCT scores relative to IQ estimates, support Torrance's (1981b) original conclusions about the predictive validity of Divergent Thinking tests.’ (p 109).

A review by Kyung-Hee Kim (2002) identified broad approval of the reliability of the TTCT reported by a number of authors (Treffinger, 1985; Torrance and Wu, 1981, Miller 2002). However, the review noted that a number of authors still questioned the value of a test of creativity that focussed on a limited number of characteristics. Cropley (2002) pointed out that the TTCT is culture bound, many of the standard tasks are well-known to students across the world (and so not novel) and that facility and flair can confuse the results. Also, Torrance’s tests measure items like flexibility and fluency in the belief that these correlate in some way with creativity and they may be better thought of as tests of divergent thinking skills. Despite these concerns, there are correlations between high scores on TTCT and creativity as recognised by peers and these tests are often used to test creativity-enhancing courses.

2.3.4.2 Consensual Assessment Technique

Described as the ‘gold standard of creativity assessment’ (Long, 2014) the Consensual Assessment Technique, CAT (Amabile,1982) provides no criteria for creativity. Rather than testing for divergent thinking as a correlate for creative potential CAT looks directly at the products generated rather than the results in a given test. Judges assess products against their conception of creativity, individually and without discussion, and produce scores which are collated to produce the ‘consensual assessment’. CAT has become one of the most common assessments of products generated by a creative process.

2.3.4.3 Creative Product Analysis Matrix CPAM

While CAT offers no guidance to its judges the Creative Product Analysis Matrix, developed over a decade (Bessemer and O’Quin, 1999), offers three dimensions with descriptions but no formal criteria. When applying the CPAM judges should consider:

- **Novelty**: The degree of newness in the product in terms of the number and extent of new materials, new processes, and/or concepts included.
- **Resolution**: The degree to which the product fits or meets the needs of the c situation.
- **Style**: The degree to which the product combines unlike elements into a refined, developed, coherent whole, statement or unit.

These areas have similarities to Torrance’s fluency (novelty and resolution), flexibility and originality (novelty) and elaboration (style).

2.3.4.4 Cropley Solution Diagnosis Scale CSDS

Another approach is provided by the Cropley Solution Diagnosis Scale CSDS, (Cropley and Cropley, 2008; Cropley and Kaufman, 2012) which assesses any creative output across factors

arranged across five zones. Each factor is provided with indicators (e.g. for ‘safety’ the indicator is ‘the solution is safe to use’ while for ‘reconstruction’ it is ‘the solution shows that an approach previously abandoned is still useful’.) Each factor is then scored against a Likert scale, with values ranging from ‘not at all’ through to ‘very much’. The authors claim that non-expert raters are able to operate with a good degree of agreement and that it is possible to rate the creativity in a wide range of fields with this tool. Originally the scale used 30 factors but tests showed six of these were of no value and so modern tests use 24 factors as given in Table 2.7.

Table 2.7: Cropley Solution Diagnosis Scale factors

Product Creativity				
Relevance and Effectiveness	Problematization	Propulsion	Elegance	Genesis
Performance	Prescription	Redefinition	Pleasingness	Vision
Appropriateness	Prognosis	Reinitiation	Completeness	Transferability
Correctness	Diagnosis	Generation	Sustainability	Seminality
		Redirection	Gracefulness	Pathfinding
		Combination	Convincingness	Germinality
			Harmoniousness	Foundationality
			Safety	

2.3.4.5 A test for creativity in science lessons

Hu and Adey (2002) developed a test specifically for scientific creativity to focus on creativity *in* science (for example generating and testing new ideas) as opposed to creativity *about* science (for example, a poster about kinetic theory). Using Torrance’s ‘fluency, flexibility and originality’ as a measure of the personal trait of a creative person they added scores for product development (the knowledge/understanding component that makes the test a measure of ‘scientific’ creativity) and the process of engaging with the problem (thinking, using imagination) to produce a model of scientific creativity that contained 24 cells (See Figure 2.8). A 7-item test was then developed to access each of these cells (each item covered more than one cell) and trialled with 160 students (aged 11,12 and 16) in a UK school. The developers reported that the internal consistency, agreement between scorers, construct-related validity and face validity of the test were found to be satisfactory. This provided sufficient confidence for the test to be used in a subsequent inquiry into the effect of a course based on the Cognitive Acceleration through Science Education project (CASE) affected the development of creativity in teenagers in England (Lin *et al*, 2003). The authors concluded that CASE did promote development of scientific creativity although it had effects that varied across the different components of the scientific creativity model.

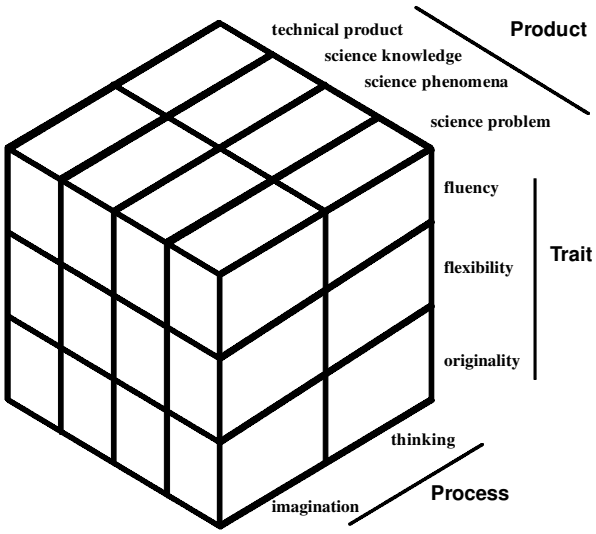

Figure 2.8: Scientific Structure Creativity Model

2.3.5 The creative environment

The environmental 'press' provides the fourth P in the 4-P classification. The KEYS model, a development of Amabile's original Work Environment Inventory (Amabile and Gryskiewicz, 1989), is one of the few instruments that explores the environmental determinants of creative activity in the workplace. It has been extensively tested and its insights deployed in businesses across the globe. This reflects the perception of the increasing importance of creativity in the business place - particularly in the high tech businesses of the 21st century. The KEYS model (Amabile, 1996) looks at five conceptual categories:

- encouragement of creativity
- autonomy or freedom
- resources
- pressures
- organisational impediments to creativity

A number of these categories are broken down further to facilitate the creation of scoring scales and to recognise that, for example, one person's perception of the level of encouragement in a organisation will depend on their position in that organisation and the agents of that organisation that act directly upon them.

Drawing on this and others' insights, Dombrowski *et al* (2007) summarised eight features of a creative environment in business as:

- innovative mission and vision statements,
- democratic communication,
- safe spaces,
- flexibility,
- collaboration,
- boundary spanning,
- incentives, and
- leadership.

The cataloguing of the features of a creative environment has been detailed and relentless. In 2009, Hsen-Hsing Ma carried out a meta analysis of 111 published studies into creativity in an educational context (he recruited all studies from databases of papers focussing on education) showing 2,013 effects of various conditions including personal and environmental aspects. He identified the important factors for increasing creativity as variables concerned with prestige of honours or awards (more prestigious rewards promoted greater creativity), working circumstances (open, friction-free classroom environments promote creativity) and aspects of problem-solving strategies (defining the problem and retrieving relevant information improve creativity).

That the environment has an effect on creativity exhibited by individuals is unsurprising. In Csikszentmihalyi's approach the environment actively recognises and validates creativity while in the work of Amabile and many others the environment can stimulate or inhibit it. However, both of these approaches assume that the creative person is largely passive with respect to the environment - it acts upon them. An alternative approach is to see the creative individual as an

agent that helps to affect their environment and even to create one conducive to their own creative endeavour by building teams and connections with individuals and institutions working in the same field.

One characteristic of the most creative companies is that creativity is not regarded as the preserve of the few but a requirement from the many. Apple's Jonathan Ive may be the design genius behind the iPhone and the iMac but even the lowest level programmer or engineer dealing with a boring subroutine or mundane circuit is still expected to think creatively about their job. These people are part of the active network that defines the company rather than being a dumb link in a chain of command or the hapless victim of an environment that is supportive or restrictive concerning creativity. McWilliam (2009) identifies a change in requirements for new graduates entering industry.

> 'They will be performing work that is less focussed on routine problem-solving and more focussed on creative outcomes that involve new social relationships, novel challenges and the synthesizing of 'big picture' scenarios.' (McWilliam, 2009 p3)

Creativity is essential in the company at every scale (company, division, team) and every level (MD, VP, team leader, individual worker). How this requirement for 'whole network' creativity translates into schools, where students are often less powerful and with less room for manouvere than their teachers or even government bodies dictating the content and style of the curriculum is unclear.

2.4 Creativity in science education

Section 2.3 reviewed some of the current understanding of creativity using the 4P distinction to build on the development of the idea over historical time covered in Section 2.2. Much of what Section 2.3 contained was developed in contexts wider than science education and with a broader remit than a clear definition of creativity in science education. However, many of the insights reported also apply to creativity in science education.

Section 2.4 will explore in more detail creativity in science education in terms of its expressed importance in curriculum guidelines, its relative absence in school science environments, some possible reasons for this mismatch and a clarification of the central research question for this study.

2.4.1 Creativity in the science curriculum

Many governments offer explicit guidance to schools concerning the knowledge and skills that should be taught at particular age ranges. This guidance ranges from optional advice to statutory instruction (particularly for government-funded schools) but all curricula indicate the relative significance of different topics and skills to the relevant country. Creativity is notable in the various curriculum documents both as a characteristic of science and as a valuable aspect of science education from a range of countries.

> ‘Scientific knowledge is a result of human endeavour, imagination, and creativity.’ (USA, NGSS, 2013. Appendix H: The Nature of Science, p6)
>
> ‘Science is the study of phenomena and events around us through systematic observation and experimentation. It involves observing, investigating, understanding, and explaining the world. It is a human endeavour and is dynamic in nature. It is derived from systematic observation, experimentation and analysis, and requires imagination and creativity.’ (Hong Kong National Curriculum, 2016, p18)
>
> ‘Creative problem solving: This is the process of thinking through a problem and choosing an innovative solution that meets the requirements. (Singapore Science Syllabus Lower and Upper Secondary Normal (Technical) 2013, p11)
>
> ‘Creativity and innovation: Creativity is an important part of the scientific process. Scientific experimentation can generate new ideas that. may not otherwise have been considered, leading to novel discoveries and applications.’ (UK National Curriculum, 2007, p212)
>
> ‘The national curriculum provides pupils with an introduction to the essential knowledge that they need to be educated citizens. It introduces pupils to the best that has been thought and said; and helps engender an appreciation of human creativity and achievement.’ (National Curriculum for England, 2013, p5)

It is worth noting that while these curricula tend to include long lists, often with detailed extra guidance, of content and practical techniques to be covered, few offer any further detail about creativity and what students would be expected to cover or achieve during their studies. While both Hong Kong and Singapore documents do identify creative problem solving as assessment objectives neither offer assessment benchmarks specifically devoted to creativity.

Government departments are keen to promote creativity in science education for a number of reasons including economic and cultural. A number of the curriculum developers and educationalists who are similarly keen to promote creativity have a slightly different reason: that science is inherently and inevitably creative (my emphasis).

> ‘Creativity experts (e.g. Florida, Sternberg, Csikszentmihalyi) have long *identified scientists at the elite level of creative worker*. Even scientists are starting to see themselves as creative workers (e.g. PKAL2007b; Boyer Report 1999; Greener 2005; Neumann 2007). Thus there must be agreement that fostering the ability to select, re-shuffle, combine, or synthesise already existing facts, ideas, and skills in original ways (Koestler 1964) is *central to the core business of science education*.’ (McWilliam, Poronnik and Taylor, 2008 p228)

Since scientists are at the ‘elite level of creative workers’ and creativity is consequently ‘central to the core business of science education’ it follows that a science education *without* creativity cannot reasonably claim to be science at all. McWilliam *et al* (2008) actually claim that the lack of creativity in many science courses is the primary cause of what they call ‘the flight from science’ (McWilliam, 2008, p226).

However, agreeing that science education should include creativity as part of its core business may be seen as yet another claim on the time of hard-pressed teachers and students facing a system that is predominantly driven by assessments that reward convergent thinking and factual recall. (Cheng, 2010). Not surprisingly, creativity in classrooms is rarer than many educationalists might hope. (Beghetto, 2007, p265)

2.4.2 Creativity and pedagogy

If the science curriculum, as defined by governments, identifies creativity as a significant part of science education (NGSS, 2013; Hong Kong National Curriculum, 2016; National Curriculum for England, 2013) it follows that the pedagogy used in the classroom to deliver that curriculum should both exhibit creativity and develop its use in science. While this thesis is specifically not about an attempt to develop a creative pedagogy (see Section P.3.1) but an attempt to understand what science teachers understand by creativity in their lessons it is worthwhile to consider the broad outlines of a pedagogy and curriculum that might be considered to support creativity.

John Dewey's ideas on curriculum and pedagogy have been significant on an international scale for over a hundred years. Dewey's work in education flowed out of his belief in democracy as a fundamental part of scientific method and society.

> 'Third, he [Dewey] insisted on the harmony between democracy and the scientific method: ever-expanding and self-critical communities of inquiry, operating on pragmatic principles and constantly revising their beliefs in light of new evidence … Finally, Dewey called for extending democracy, conceived as an ethical project, from politics to industry and society.' (Westbrook, 1992 p 919)

The 'scientific method' described above would be very familiar to scientists operating today and the notions of 'ever-expanding' and 'self-critical' will look like 'divergent' and 'convergent' thinking to many academics exploring creativity. When Dewey calls for 'extending democracy' he does not mean a simple transfer of voting mechanisms from the political to the educational context but a shift away from centralised power to a more egalitarian and participatory system. This acceptance that the student is an integral part of the education process as opposed to merely a recipient of it appears throughout Dewey's work and is picked up later by others including Freire and the radical de-schooler Ivan Illich (Miettinen, 2000).

However, while Dewey emphasised the importance of the student and their active engagement with their learning he was critical of some versions of 'child-centred' education where the student has total control over what is covered.

> 'I believe that these interests [the student's interests]are neither to be humoured nor repressed. To repress interest is to substitute the adult for the child, and so to weaken intellectual curiosity and alertness, to suppress initiative, and to deaden interest. To humour the interests is to substitute the transient for the permanent. The interest is always the sign of some power below; the important thing is to discover this power. To

> humour the interest is to fail to penetrate below the surface, and is sure result is to substitute caprice and whim for genuine interest.' (Dewey, 1897, p15)

The desire to avoid 'caprice and whim' in Dewey's thinking links neatly to the notion of domain knowledge in Csikszentmihalyi's thinking and the observation that creative people working within a domain are typically most productive after a period of study where they master the relevant domain knowledge (Csikszentmihalyi, 1996).

Dewey argued for a curriculum that is based around experiences (which modern teachers might describe as 'experiments' or 'hands-on activities') rather than symbols (by which he predominantly meant reading and writing) with a pedagogy to match this. While he did not denigrate the valuable skills of reading and writing he ascribed some of the problems he perceived in education and learning at the time to the exclusive pursuit of these skills. He also claimed that experiences, which he referred to as actions, not only improved learning, compared with simple manipulation of symbols, but that learning itself was an inevitable outflow of actions as the learner sought to understand their environment and consequently manage their actions within it more effectively. In *My Pedagogic Creed* (1897) Dewey was particularly clear on the centrality and purpose of action (my emphasis).

> 'I believe that ideas (intellectual and rational processes) also result from action and evolve for the sake of the better control of action. What we term reason is primarily the law of orderly or effective action.' (Dewey, 1897 p14)

Dewey's thinking has produced a range of other offshoots drawing on the same experience-reflection process. Active learning, Problem-Based Learning and inquiry-based approaches are all influenced by Dewey's pedagogic creed and his subsequent writings and stand as a contrast to the more content-driven, teacher-led pedagogies that are becoming increasingly popular with some right-wing politicians in the UK and the US. So, while much of modern 'progressive' teaching strategies owe a great deal to Dewey and there is a clear link between Dewey and modern inquiry-based science education (Bevins and Price, 2016) is there any link between Dewey and a creative pedagogy? Given that there is already a confusion between good, progressive teaching and creativity (Kind and Kind, 2007) will citing Dewey merely add to the confused pedagogical jumble or help us better understand any links between creativity and good science teaching?

Dewey also wrote about creativity on more than one occasion (Dewey, 1934, 1958) but focussed on the creative experience, the act of creation, in a way that pre-figures Csikszentmihalyi's work on 'flow' as an almost ecstatic involvement in a creative task (Csikszentmihalyi, 1996). Indeed, Dewey's model of reflective thought and action (Miettinen, 2010) shows stages that can be clearly linked with divergent and convergent thinking - two key aspects of many models of creative thinking.

In summary, while this thesis is not about finding a 'pedagogy for creativity' the issues arising during the literature review and initial discussions are not outposts of a bizarre anti-school or revolutionary pedagogy but are prefigured in work of Dewey, and others following on from him

over more than 100 years. Dewey's contribution to the creative pedagogy discussion includes the idea that students can be 'creators' as opposed to merely a 'recipients' of learning, the suggestion that schools should be democratic environments where ideas can be presented by any members and that creativity (or the specific act of creation) has a valuable, almost ecstatic, aspect which should be part of every child's education.

2.4.3 Creativity in the science classroom

2.4.3.1 Classroom experiences of scientific creativity

Despite the ubiquity of creativity in science as practised by scientific researchers and science in published curricula (Hadzigeorgiou, Fokialis and Kabouropoulou, 2012), a number of authors have lamented that it is not always present in the science experienced in schools by students. In a summary of much of the available research Gralewski and Karwowski (2016) noted a number of problems (the emphasis is mine).

> 'Although teachers are usually convinced about the importance of creativity, with most of them believing that students' creative potential can be developed (Kampylis, Berki, & Saariluoma, 2009), which results in a growing rather than fixed creative mindset (Beghetto, 2014; Karwowski, 2014), many do not feel responsible for the enhancement of students' creativity (Aljughaiman & Mowrer-Reynolds, 2005; Beghetto, 2007). *Even worse: many teachers seem not to fully understand what creativity actually is* (Andiliou & Murphy, 2010; Cheung, Tse, & Tsang, 2003) and wrongly, or at least incompletely, characterize creative students (Chan & Chan, 1999; Karwowski, 2010; Runco & Johnson, 2002; Westby & Dawson, 1995).' (Gralewski and Karwowski, 2016, p1)

These claims matched earlier ones from Beghetto (2007) who again notes the discrepancy - teachers approve of creativity but actively work against it (emphasis mine).

> 'Most teachers value creativity. It is therefore unfortunate that so few actually support creative expression in their classroom (Runco, 2003; Strernberg, 2003). In fact, for nearly half a century researchers (Torrance, 1963, 1965) have documented that *teachers often undermine student creativity*.' (Beghetto, 2007, p265)

In a study of creativity in the science classroom in Oman (Al-Abdali and Al-Balushi, 2015) the classroom practice of 22 science teachers working in Grades 5-10 was observed to assess their degree of support for creativity. The researchers had previously produced an observation schedule (Teaching for Creativity Observation Form) based on published work concerning teaching for creativity in science. The TCOF had been reviewed by a panel of 12 judges (3 professors of education, 2 professors of psychology, 7 science supervisors from the Oman Ministry of Education) and was judged fit for purpose following minor amendments. The form addressed four categories of teacher activity (questioning strategy, teachers responses to student ideas, classroom activities that are different from standard lecture-discussion work and whole class strategies to promote creativity such as brainstorming, creating mind maps) across 23 items. The researchers then carried out observations, using the TCOF, in the classrooms

producing 66 lesson observation datasets. They suggested that science teachers offered very limited support for the creative development of their students. The most successful aspect of teachers' work they identified, from the point of view of creativity, was the willingness to respond to students' ideas. When the teachers were confronted with the data and interviewed about their apparent lack of support for creativity three key factors emerged. The first was the pressure created by high-stakes assessments which encouraged teachers to teach simply for the examination. These assessment-driven demands used up considerable time that could have been used for more creative endeavours. The second and third issues revolved around teachers feeling that they had had little professional support concerning the meaning of creativity in science and how lessons might be constructed to support it.

A study in the US (Meyer and Lederman, 2013) looked at how 17 teachers working at secondary level integrated creative activities into their lessons. 16 teachers of the 17 claimed that they valued opportunities for their students to demonstrate creativity. However when they completed a simple questionnaire five of them produced responses to the instruction 'Give an example of an activity, lab, worksheet, etc. that you have used with your classes that shows scientific creativity among your students' that were so vague that they had to be ignored. The remaining 11 produced some examples and a subset of these were involved in a more detailed classroom observation exercise (See Section 2.4.3.4 for details of the study into those teachers).

However, the reports of science teachers' poor performance with regard to creativity in their classrooms might be an artefact of how the tests were applied, specifically in looking for creativity support in individual teachers. As McWilliam (2008) suggests (my emphasis):

> '… we need to unhook creative capacity from an individual psychology and understand it as a 'team' capacity. Mihalyi Csikszentmihalyi (1999) insists that it is the community, *not the individual*, who ought to be the unit of analysis in any investigation into how creativity gets fostered. (McWilliam, 2008 p231)

The sections that follow look at three impediments to implementation of a science curriculum's plans for creativity: the nature and significance of assessment packages, science teachers' understanding of the nature of creativity in science and their pedagogical skills in converting curriculum aims into learning experiences for students.

2.4.3.2 Creativity and curriculum narrowing

The negative effects of high-stakes testing and a focus on assessments are not limited to creativity or to science (Berliner, 2011). In the USA, a focus on reading and mathematics at primary school level led to a reduction in time for all other activities with science losing 33% and art and music 35% on average (McMurrer, 2008).

Berliner called this response to high-stakes assessment 'curriculum narrowing' (Berliner, 2011) and cited it as only one aspect of the 'plethora of negative side effects associated with high stakes testing' (Berliner, 2011 p287). Curriculum narrowing involves a reduction of what is taught into what is assessed, both in terms of subjects (the move away from subjects that are not

reported in national assessments, e.g. music) and cognitive activities (the move away from difficult-to-mark activities involving higher order thinking skills towards simple-to-check remembered facts - the 'spellings, facts and rules' identified in the letter to Michael Gove in Section 1.2.4.2 The costs of creativity).

Given the extra pressure to produce results, teachers opt for strategies that they feel confident will work and these tend to involve revision lessons, exam practice sessions and a general reduction in the more open-ended, less predictable activities that support creativity.

2.4.3.3 Science teachers' understanding of creativity

One of the factors cited to explain the relative absence of creativity in science lessons is that science teachers have limited understanding of what creativity means in this context. Indeed, this lack of clarity about creativity in science education is part of the justification for this study, as explained in the preface.

In a review of 131 science teachers' understanding of creativity (Gralewski and Karwowsky, 2016) four classes of teachers were identified each of which ascribed slightly different characteristics to creative students. Notably, in two of the classes self-control and perseverance figured highly while inventiveness and problem-solving ability did not. In another class, impulsiveness and indiscipline was seen as key features of creativity - alongside a lack of perseverance. This confusion meant that teachers were unable to recognise creativity as described by standard definitions (i.e. novelty and value) in their students and certainly not to teach in away which supported its development.

> 'Let us put it simply: teachers are usually poor in recognising their students' creative potential - at least these aspects of creative potential that creativity tests measure' (p2).

This problem is not unique to teachers navigating the day-to-day pressures of classroom management, over-filled curriculum demands and the demands of a restrictive assessment system. Newton and Newton (2009), from Durham University, looked at the perceptions of scientific creativity in student teachers destined for primary schools (and so expected to teach science and technology). The students readily accepted 'practical work' as being creative and identified opportunities for students to 'build things for themselves' (e.g. making physical models). They also saw creativity in science as being about children enjoying science and the general positive atmosphere of the lesson. However, most of the students did not mention generating ideas from scientific ideas or using imagination to solve problems (outside the technological 'build it and test it' type of activities) as examples of creativity.

If teachers value creativity but find it difficult to recognise it in their practice, or the students they teach, they may simply equate it with good teaching and so avoid the issue. This default to 'good teaching' may be, in part, a result of advice offered to teachers about pedagogy by curriculum developers and educational researchers. Kind and Kind, in their 2007 review of teaching approaches in the science education literature, found that 'creative' was always associated with

'good teaching' in general in contrast to 'bad traditional' teaching. Table 2.9 summarises their review.

Table 2.9: Common contrasts in science education literature

'Good' creative teaching	*Bad traditional teaching*	
Student-orientated	Teacher-orientated	Melar, 1993
Group/team work	Individual work	Marazz1,1999
Cooperative learning	Individual learning	Anderson, 2001
Explorative tasks	Close-end tasks	Saxon et al, 2003
Open-ended problems	Closed problems	Schamel and Ayres, 1992
Open investigations	'Recipe-style' work	Sallam and Krockover, 1982
Hands-on teaching	Lectures	Shymansky and Penick, 1981
Outdoor activities	Classroom activities	Boss, 2001
Project work	Lectures	Mackin, 1996
Issue-orientated	Concept-orientated	Penick and Yager, 1993
Teachers taking risks	Teachers playing safe	Tamblyn, 2000

In an attempt to clarify what is meant by 'scientific creativity' and distinguish it from simply 'good teaching' Kind and Kind (2007) explored the meaning of 'scientific creativity' in its relationship to science education in schools. They identified the use of imagination, images, analogies and models to push forward understanding and make predictions as a key feature of scientific creativity quoting kinetic theory as an example of a model or analogy that students could use to extend their understanding and develop insights and predictions (the 'novelty' or 'originality' typical of creativity definitions) which could then be tested by strategic experimentation (the corresponding 'value' aspect).

While the authors admitted that much of this thinking was new and needed greater research, they talked of 'taming' the concept of scientific creativity by making aspects of it more concrete and understandable. The list of statements which they offered as a picture of scientific creativity are given below (no hierarchy implied, the numbers are to facilitate references int the following paragraph.

1. Scientific theories are creative products (ideas) made by scientists
2. Many scientists work on the same problems and new ideas (theories, laws) emerge by common effort.
3. Most science theories develop over a long period in small steps.
4. Some scientists are highly creative and make substantial contributions in their fields, but they always build on other people's ideas.
5. All scientists must use their imagination when contributing to the development of science.

6. Scientific theories are created in many different ways. The processes are sometimes highly creative and/or highly logical, rational and/or accidental.
7. In science creativity and rationality always work together. Scientific creativity never works without rationality and strict empirical testing. (Kind and Kind, 2007. p14)

These statements still provide an useful view of the nature of scientific creativity and include a sense of collaboration (points 2 and 4); extended development times (point 3); divergent (points 5 and 6) and convergent thinking (points 6 and 7) alongside even a reference to random inspiration (point 6). Underlying these are the notions of novelty and value shared with other views of creativity (Sternberg, 1999).

One of the problems with defining 'creativity in science education' is that there is often a confusion between creativity *in* science (the creativity inherent in the processes of science drawing on the domain of scientific knowledge) and creativity *about* science (creative approaches to communicating science). In a creativity *in* science activity the removal of the science domain knowledge makes the activity impossible. For example, without a scientific understanding of kinetic theory it is impossible to make reasoned predictions about the behaviour of a gas in a vessel. In activities that are creativity *about* science it is possible to remove the science domain knowledge, replace it with some other discipline, and the activity remains valid. In this instance creating a poster about the way low pressure can lead to increased rainfall is a valid creative act but the poster could equally well be about the artists of the Italian renaissance or the albums of a 1970's progressive rock band. Table 2.10 provides exemplars of the kinds of activities these different approaches would generate. All the exemplars are taken from published resources used in schools in the UK and internationally and some were produced by colleagues at SHU.

While it is useful to think of these two aspects of creativity in science lessons it should not be assumed that they are mutually exclusive - so an activity that involves predicting what might happen if gravity on Earth was significantly stronger (divergent and predictive thinking) is clearly creativity *in* science but if the output involved a scripted play (with specified duration, number of characters etc.) or cartoon sequence about life on this imaginary Earth this could *also* be an example of creativity *about* science. If the predictions about this high gravity Earth were random or based on students' viewing of Star Wars then it would be simply creativity *about* science.

Similarly, many of the exemplars listed in Table 2.10 for creativity *about* science could be very useful vehicles to promote predicting and assessing ideas (creativity *in* science) although the focus of each activity is currently on the output format with a consequent danger that the students would spend far more time considering the colours to be used in the poster than considering strategies for ecosystem protection.

Table 2.10: Creative activities 'in' and 'about' science

Typical activities that promote creativity 'in' science	*Typical activities that promote creativity 'about' science*
Plan an investigation into how the percentage of fat in a meat sample affects how well salting can preserve it. (Make the Link, 2012)	Students develop a poster for their school showing simple ways in which their country's ecosystem might be preserved, e.g. using less paper to save endangered trees. (Hebat sains, 2013)
Find a way of containing toxins and to clean the water releasing water pure enough to enter water courses that lead to reservoirs for potable water. (Engineering Thailand, 2014)	Create a leaflet to explain to members of the public the dangers of climate change and the measures they can take to reduce their carbon footprint (Make the Link, 2012).
Predict the likely effect of decreasing particle size on the rate of dissolving of medicines in drug capsules. (Active Science, 2005)	Prepare a simple presentation to tell people how to choose the correct fuse for every appliance. The presentation will be self-running and will be shown in a display unit which is selling fuses at a DIY shop. (Entry Level Science, 2015)
Changing the rules! An exercise in predicting what might happen if the rules governing the interactions between particles were changed (e.g. increasing or decreasing the forces of attraction/repulsion between them). (Teach Better Science, 2013)	Ecotours Ltd. Produce a website to promote ecotourism as a strategy to support conservation of the rainforests of Brazil. (Teach Better Science, 2013)

While Kind and Kind's description in 2007 applies to creativity *in* science creativity *about* science often looks like 'good teaching' as is revealed by Table 2.9 where 'good creative teaching' is contrasted with 'bad traditional teaching'. Unfortunately, by defaulting to 'good teaching', teachers can avoid reflecting about the impact of their practice on students' creativity. If lessons are student-orientated, use group or team work and involve open investigations then it is tempting to believe that they are, almost by definition, creative. However, most research recognises creative products in terms of novelty and value (see Section 2.2.3.8: An agreed definition of creativity) not because of 'hands-on teaching' or 'open-ended problems'.

Despite this distinction, the working definition of creativity in science education, as stated in the preface (See Section P.4.2), conflates these two issues somewhat.

> Creativity in science education involves the production of novel ideas, approaches or objects that serve some purpose in the extension of scientific understanding or have some value in the context of engaging learners with scientific domain knowledge and practices.

The production of 'novel ideas, approaches and objects that serve some purpose in the extension of scientific understanding' is clearly about creativity *in* science while it accepts that there is some value to be ascribed to 'engaging students with scientific domain knowledge and practices' which references creativity *about* science. This is not accidental and reflects the aims and context of science education, which seeks to support the development of scientific knowledge and skills in

the student, as opposed to the practice of professional or research scientists, which is to extend the sum total of scientific knowledge.

A further issue confusing the understanding of creativity in science lessons is the distinction between 'teaching creatively' and 'teaching for creativity' (Jeffrey and Craft, 2004). While this distinction does not only concern creativity in science lessons it will have an impact on science teachers and their students. As Jeffrey and Craft (2004) make clear (their own emphasis), there is a significant difference.

> 'The NACCCE report (1999) made a distinction between *teaching creatively* and *teaching for creativity* in its characterization of creative teaching. The former is defined as 'using imaginative approaches to make learning more interesting and effective' (ibid. p. 89). Teaching for creativity is defined as forms of teaching that are intended to develop young peoples own creative thinking or behaviour.' (Jeffrey and Craft, 2004 p77)

While they accept that this distinction may be useful when considering classroom approaches they warn that this 'a new dichotomy' could become formalised implying that teachers would opt for one or the other. This seems borne out by Kind and Kind's later findings (Kind and Kind, 2007) that teachers, and many curriculum developers, were equating 'teaching creatively' with using inquiry methods, child-centred approaches and various progressive strategies with creativity itself. Jeffrey and Craft suggested that teaching creatively and teaching for creativity were often combined and that any distinction in the classroom often depended on the students' activity (e.g. taking opportunities to develop their own learning) as much as in the teacher's intention (i.e. the original lesson plan.)

> 'They did this [teach for creativity] by firstly making teaching and learning relevant and encouraging ownership of learning and then by passing back control to the learner (Jeffrey and Craft, 2003) and encouraging innovative contributions.' (Jeffrey and Craft 2004 p 81)

This required students to become active owners of their learning, a feature that also appears in McWilliam's (2008) insistence that students should be seen as co-constructors and producers of knowledge not merely consumers of pre-built knowledge.

> 'Rather than teachers delivering an information product to be 'consumed' and fed back by the student, co-creating value would see the teacher and student mutually involved in assembling and disassembling scientific knowledge. As co-creators, both would add value to the capacity building work being done through the invitation to 'meddle' (McWilliam 2005) and to make errors.' (McWilliam, 2008 p 229)

In summary, the understanding of creativity in science education varies amongst practitioners. For some it is primarily about engaging approaches to teaching which make science 'fun' while others emphasise a wider range of 'progressive' pedagogies. It can involve creativity about science (posters and presentations about science content) or in science (creating new scientific ideas). For others it involves a significant change in teacher role not just the content and skills taught. In

McWilliam's redraft of an old teaching and training trope, creativity involves a move from 'the sage on the stage' but not simply to the guide at the side'.

> 'They [teachers] could extend the repertoire of their pedagogical repertoire, beyond "Sage-on-the-Stage" or "Guide-on-the-Side", to include a third role for the twenty-first century teacher as a builder of creative capacity – that of "Meddler-in-the-Middle". (McWilliams, 2009) p 287)

The lack of a clear understanding of creativity in science lessons seems to be at the route of many problems. The next section explores the potential impact of this lack of understanding on teachers' practice in relation to creativity.

2.4.3.4 Teachers' skills and creativity

Teachers seeking help to develop their 'creative teaching skills' are not short of advice. A routine internet search with the search term 'teaching more creatively' produced over 18 million hits in July 2018. The top five hits were '8 steps to becoming a more creative teacher', '19 ideas to promote creativity in your classroom', '101 ways for teachers to be more creative' '20 Clever ways to teach creativity in the classroom' and '14 Creative ways to engage students'. At first glance, this seems to provide a rich, practice-orientated resource for teachers. However, on visiting the sites, much of the advice turns out be very general with considerable repetition between the different sites. Most suggest things like 'Integrate more hands-on learning', 'Introduce unconventional learning materials', 'Encourage discussion', 'Be open to new ideas', 'Think outside the box', 'Embrace weirdness' and 'Question assumptions'. While none of these suggestions have no value most are probably so general as to be unhelpful for busy teachers who are also facing the more concise and carefully-structured demands of their syllabus documents and assessment systems. A teacher faced with the requirements to cover kinetic theory or the factors affecting the yield of crop plants might find it difficult to go from 'Think outside the box' to a learning experience for their own classroom. The advice, broadly, merely reflects the 'progressive teaching good, traditional teaching bad' simplification reported in the learned journals articles by Kind and Kind (2009) and offers little specific, useful advice to teachers seeking to upgrade their skills in the area of supporting creativity in science lessons.

The study by Meyer and Lederman (Meyer and Lederman, 2013) described earlier illustrates the difficulty teachers find in converting this general advice into specific classroom strategies. Of their original 17 teachers who claimed to offer opportunities for students to develop creativity 11 were involved in a classroom observation activity. To reflect on the classroom observations the authors developed a model which drew together the classic features of creativity (fluency, flexibility, originality) on the left with the key aspects of classroom experiences on the right. This is illustrated in Figure 2.11.

For an activity to qualify as a strategy to teach scientific creativity it had to offer potential for divergent thinking (shown on the left of the diagram) and have a complex of pedagogical factors (shown on the right) that could optimise student learning. The observational data was categorised

to reveal a number of key issues including the distinction between flexibility (the possibility of multiple solutions which encouraged creativity) and ambiguity (the lack of clear direction which encouraged disengagement and drift); the status and style of questions within the classroom (both teacher-student and student-student) and openness to alternatives (a willingness to build on, and adopt, suggestions of others encouraged creativity). This revealed that even where teachers claimed to be supportive of creativity and had an understanding of what creativity in science education meant their skill sets were somewhat lacking.

Discussing their findings, Meyer and Lederman identify two related problems with creativity in science lessons: lack of understanding of creativity and a lack of skills to deliver it.

> ‘The activities that the teachers claimed supported student creativity had two main problems. They seemed either to lack explicit consideration of creativity or to demonstrate misconceptions about the efficacy of certain types of activities for the purpose of supporting student creativity.’ (p407)

While the lack of specific skills with regard to creativity is significant, even if these skills were present they may not be deployed if science teachers cannot recognise the incidents where they would be appropriate.

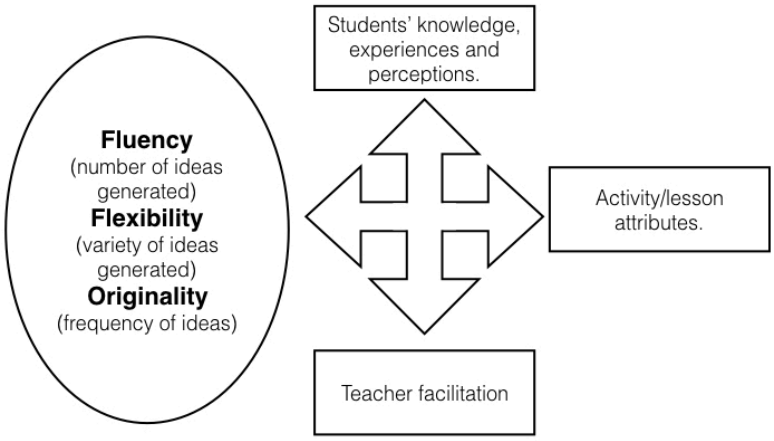

Figure 2.11: Creative thinking in the science classroom analysis framework

2.5 Research question

The literature concerning creativity is extensive and at least four separate approaches (person, process, product and press) to the study of it are available and active (Rhodes, 1961). It is valued for its cultural, economic, personal and educational benefits and is seen as a key component of scientific research and education. However, there is limited work concerning creativity *in situ* in science classrooms beyond the attempts to improve creativity by altering teaching approaches or classroom environments - often with prescriptions that reflect strategies developed for the business environment or other subjects (e.g. art, design).

Science teachers are described as being unable to distinguish between creativity and 'good teaching' (Kind and Kind, 2007), have limited skills to support creativity in their students (Meyer and Lederman, 2013) and generally fail to support students' creative development (Gralewski and Karwowsky, 2016). However, few studies have explored what science teachers do understand by creativity in their classrooms, as opposed to failing to understand others' definitions of it. Consequently, this study will explore this aspect and seek to answer this question: what do science teachers understand when they talk of creativity in their science lessons? How do they recognise creative situations in their lessons? How do they behave in this way and what guides their behaviour? This then will become the research question for this study.

To focus this study it will use the definition of creativity provided in the preface.

> Creativity in science education involves the production of novel ideas, approaches or objects that serve some purpose or have some value in the context of engaging learners with, or developing, scientific domain knowledge and practices.

However, while this definition provides an initial guide the emphasis will be on seeking to listen to secondary school science teachers to understand what *they* understand by creativity, how *they* recognise and experience it in *their* classrooms. The formal research question then becomes:

> What do secondary school science teachers understand by creativity in their classrooms?

2.6 Reflection

In this chapter I have shown that the notion of creativity has changed moving from a sense that it was god-given, rare, exhibited mainly by special individuals and highly disruptive to being seen as a more widely-distributed and normal part of human experience with effects ranging from small-scale decisions to giant leaps forward in understanding for the whole human race (See Table 2.4, Section 2.2.3.7). The discussions about the exact definition of creativity continue today with a general agreement that novelty and value are central but with a range of other characteristics added by different researchers (Compton, 2010; Amabile, 1996; Boden, 2004).

Reflecting the significance of creativity described in Chapter 1, there is considerable ongoing research into its nature and how it can be stimulated and supported in business and education.

My original interest in creativity seems to be widely shared. This research effort involves a wide range of methodological approaches but can be usefully summarised around four large domains: person (what are the characteristics of a creative person?), process (how are creative insights generated?), product (what is a creative product and what are the indicators of creativity in action?) and press (what effects does the environment have on creativity?). It is perhaps disappointing that relatively little of this work has been deployed in the field of science education, with notable exceptions, where creativity remains a rarity (Gralewski and Karwowski, 2016).

The final section of the chapter considered the role of creativity in science education noting that much of what teachers did tended to reduce the need for, and use of, creativity in their students. The pressures of a content-heavy curriculum, a punitive assessment regimen and a drive to accountability reduce the opportunity for creative work across all subjects but particularly in high-status subjects like science and mathematics (Berliner, 2011). Again, creativity appears to be a proxy for other disagreements in education. ‘Creative teaching’ is typically associated with ’progressive teaching’ which means that more traditional teachers and educational systems tend to work to minimise any hints of activities or approaches which might look like creativity while ‘progressive’ teachers often confuse ’child-centred’ or ’progressive’ teaching approaches with creativity and substitute small group work or practical activities for authentic creative activity. Underlying this problem is a lack of understanding of what creativity means to science teachers beyond novelty. Looking for a clearer understanding of what science teachers understand by creativity in their classrooms thus becomes the significant issue to address in this study and generates a formal research question: ‘What do secondary school science teachers understand by creativity in their classrooms?’

In Chapter 3 I explore the issues around a suitable methodology for addressing this question looking for an approach that reflects authentic teacher understanding.

Chapter 3: Methodology

3.1 Introduction

In Chapter 2, I reviewed the current understanding of creativity as it applied in science education and recognised that, despite a long history of creativity in education, a strong push towards the value of creativity by some curriculum developers and an expressed willingness by many teachers to engage in creative work, the experience of many students in science classrooms was anything but creative. A number of reasons were suggested for this but a significant issue seems to be that science teachers' understanding of creativity is reported as being poor (Gralewski and Karwowsky, 2016). This statement causes me some problems. The vast majority of research into creativity in science education has been done by researchers with experience in education or creativity and has involved quantitative tests of creative performance (Long, 2014). While this is useful it does not always allow the teachers' voice to be heard and their understanding of creativity to be picked up. Do science teachers have a good understanding of creativity and the issues this raises in their classrooms that is different from, and potentially invisible to, the standard understanding of creativity researchers? Simply applying divergent thinking tests or even classrooms observations looking for pre-defined creative activities might miss this alternative understanding.

For this reason I wanted to find an approach which would focus on the teachers' voice and support an in-depth understanding of their perception of what creativity meant in their classrooms. This was not a straightforward search and, as this chapter describes, I looked through a number of methodological approaches before eventually settling on one that draws on Personal Construct Theory (Kelly, 1955).

This chapter describes the thinking behind the choice of methodology and leaves the procedural details of the actual method to Chapter 4 which follows.

3.2 Context of the study

This section details the context of the study in terms of the environment in which it will take place (secondary schools in England) and the focus of the study (science education at ages 11-16). It also reviews the methodological framework selected for the study (PCT) giving the reasons this approach was selected from other available options.

3.2.1 Science Education in secondary schools in England

Science has been a compulsory part of the experience of pupils aged five to 16 in England since the first National Curriculum (NC) was formulated in 1989 (DFES, 1989). The statutory element of the curriculum has changed in terms of the exact domain knowledge content included (e.g. inclusion or removal of genetic engineering, Earth Science) and at what level (e.g. the movement

of the Periodic Table from ages 14-16 to ages 11-14 years in 2008) and even the degree of direction implied (e.g. highly specific content items in the 1989 document or broader guidelines to key ideas in the 2013 version). While the degree of specialisation in, or integration between, the three traditional disciplines (Biology, Chemistry and Physics) has always been, and remains, a contentious issue in secondary schools there is a broad agreement that science education should be 'balanced', i.e. students should not be allowed to opt for a single discipline and avoid exposure to the others completely and should take up a significant amount of student time.

Changes since 2010 have further complicated the situation with a rise in the number of secondary schools becoming academies. By 1 November 2016 two thirds of all secondary schools had converted to academies (DFE, 2016). Academies, even though they are state-funded, are not required to follow the National Curriculum so students in such schools could be studying a science curriculum that is radically different from that described in the NC or even, theoretically, avoid science altogether. However, with the exception of some faith and free schools which adopt a non-standard, faith-based view of evolution, most secondary schools in England follow broadly the same science curriculum and put their students forward for GCSE at 16.

Throughout these changes, a consensus view has been that a version of science should remain a core of the secondary school experience for all pupils in England and students typically spend between 10 and 20% of their school experience in science lessons.

3.2.2 Creativity in the science classroom

While the idea of 'science' as a school subject would be largely familiar to teachers from across all types of schools the concept of creativity would be much more varied. The specific issues with regard to creativity in science education have been discussed in Section 2.4 so will not be rehearsed here except to note that the definition of creativity in science lessons is open to discussion, that there is a distinction between teaching creatively (arguably a responsibility of every teacher) and teaching creativity and that creativity can be exhibited by teachers or students, or both, in a lesson. For the purposes of this study creativity in science education is defined as 'the production of novel ideas, approaches or objects that serve some purpose or have some value in the context of engaging learners with, or developing, scientific domain knowledge and practices.' (See Section P4.1)

3.2.3 The school environment

The environment in which this complex concept operates is, in itself, complex. A school community is made up of people (e.g. students, teachers, admin and support staff, governors and parents) responding to a range of internal (e.g. timetables, room allocations, teacher availability, homework requests) and external (e.g. level of capitation, government control of the curriculum, OFSTED inspections, local and national press interests) pressures many of which are changing daily and some of which may be contradictory. Teachers have to live within, and navigate through,

this changing environment. These pressures will, directly or indirectly, affect teachers' opportunities to act creatively and may well influence their understanding of creativity informed, as it is, by their experience of creative activities and situations. If a school timetable is so pressured that the teacher feels there is no time to do anything out of the ordinary (a key characteristic of creative activity) they could begin to associate creativity with an unreachable perfection rather than an everyday option for them and their students. In this way, their personal ideas about, and experiences of, creativity are likely to be heavily constrained by their day-to-day experiences and consequently may change many times during a teacher's career.

In a complex, high-stakes environment, which is prone to sudden changes imposed from outside, the search for a teacher's understanding of a concept that may be essentially contested, open to multiple definitions and probably unstable, is a daunting task.

Any methodology must be flexible (allowing changes in response to growing data and insights), productive (leading to production of a theoretical understanding which could be related usefully to other instances as opposed to merely descriptive insights) and practical (being possible within the timeframe and constraints of the project). Section 3.2.4 describes the reasons for choosing a methodology based in Personal Construct Theory.

3.2.4 Choosing a methodological framework

3.2.4.1 Decision parameters

The motivations for this study were described in the Preface so will not be rehearsed here beyond saying that the decision to focus on developing an understanding of science teachers' understanding of creativity in their classrooms was clarified while reading the research literature and searching for a methodological framework. This clear objective was not present at the start of the study. This meant that a number of frameworks were considered, and rejected, prior to opting for an approach based in Personal Construct Theory (Kelly, 1955). However, despite the lack of a clearly defined research question throughout this exploratory early phase of the study, a number of parameters were clear.

Firstly, the study would explore a complex problem in a complex situation as described in the previous section. This complexity made quantitative research problematic. Finding relevant, reliable and appropriate numerical measures of many of the key factors was deemed unlikely in the timescale available. Measuring creativity remains problematic and the results from even long-standing tests are open to dispute (See Section 2.3.4, for a longer discussion about creativity tests). Given these issues, and the decision to seek a deeper understanding through a highly focused study with a relatively small number of participants, a qualitative approach that produced rich data, unstructured by reference to pre-existing questions or test methods, was chosen.

The second issue revolved around the desire to hear the voices of teachers on this topic. This implied a participatory approach and an analysis strategy that would focus on their words. The third concern was practicality given the limited time and resource available: a detailed

questionnaire of 300 teachers with a set of follow-up interviews and classroom observations was simply not possible or appropriate in this context.

Three methodological frameworks were considered for this study against the criteria of ability to deal with rich, qualitative data, teacher involvement and practicality: Action Research (McNiff, J; Whitehead, J., 2005), Grounded Theory (Glaser and Strauss, 1967) and Personal Construct Theory (Kelly, 1955). These are considered in the following section.

3.2.4.2 Action Research

Action Research (AR) combines a rigorous method of data collection with a period of reflection leading to action which allows further data collection in a continuous cycle of change (Kemmis and McTaggart, 1988). AR has been used extensively in educational circles to drive curriculum development projects, teacher Continuing Professional Development (CPD) and research into teaching approaches. AR has also been used in a collaborative setting (Bevins and Price, 2014) and is supportive of participants who have limited previous research experiences allowing them to contribute with confidence.

AR also seeks to narrow a perceived gap between research and practice (Ainscow, Booth and Dyson, 2004). Many reported uses of AR involve active collaborations between academics and teachers. The co-production of knowledge, where teachers work with academics as colleagues and are not simply subjects of research, has a significant history with a variety of participants who demonstrate a wide range of research experience within the education community (Cordingley *et al,* 2003; Ponte *et al*, 2004; Borko and Putnam, 1998).

For these reasons, AR seemed like an excellent methodological fit when the project was conceived of as a research-led curriculum development initiative. However, as the emphasis changed slightly to a more theoretical exploration of the nature of creativity in the science classroom the suitability of AR was questioned. AR, with its emphasis on action, is suited to development projects where the output is a product of some sort that can, in turn, be used by others. If the research project was to produce a set of trialled and optimised teaching and learning resources (as originally conceived) AR would have been very suitable. However, the shift to a more in-depth exploration of teacher conceptions of creativity changed the nature of the research and led towards a more research-heavy approach. Seeking for this, the use of Grounded Theory (Glaser and Strauss, 1967) was considered.

3.2.4.3 Grounded Theory

Grounded Theory (GT) was first described as a methodology by Glaser and Strauss (1967) who sought to establish a way for researchers to develop theory directly from data rather than being overly influenced by 'grand theories' of social research which were dominant at the time. Their book, *The discovery of Grounded Theory (1967)*, included a clear statement of the reason for its existence.

> '... we are also trying, through this book, to strengthen the mandate for generating theory, to help provide a defence against doctrinaire approaches to verification ... It

should also help students to defend themselves against verifiers who would teach them to deny the validity of their own scientific intelligence' (p.7).

Glaser and Strauss identified the 'verifiers' as those researchers who sought to push all incoming data into existing models and theories - whether it fitted or not. As a further protection against the 'grand theories' the book is uncompromising in its advice.

'… literally to ignore the literature of theory and fact on the area under study, in order to assure that the emergence of categories will not be contaminated …' (p.37).

Induction and a naivety about the underlying theories would force the researcher to depend exclusively on the data. This would give a clearer picture of what 'is' rather than what the researcher 'expects to be'.

Charmaz (2000, 2005, 2006) developed Grounded Theory using constructivist ideas claiming that any 'data' are an interpretation of the world rather than a disembodied, exact representation of it. In this, according to Charmaz, data are not dissimilar to theory in that both are constructed rather than discovered. She makes the difference between her approach and that of Glaser and Strauss clear in her book, *Constructing Grounded Theory* (2006).

'Unlike their [Glaser and Strauss] position, I assume that neither data not theories are discovered. Rather, we are part of the the world we study and the data we collect. We construct our grounded theories through our past and present involvements and interactions with people, perspectives and research practices.' (p10)

More recent GT theorists have adopted a more pragmatic approach. Since researchers are extremely unlikely to be wholly ignorant of all the theory relevant to an area it might be better to use theory intelligently but sensitively. Thornberg (2015) talked of 'informed grounded theory' which recognised the dangers of 'contamination' of analysis by existing theories while insisting that this underestimated researchers' ability to reflect upon the possible links between extant theories and their own data and its analysis.

While Grounded Theory offered a rigorous approach to the research task its focus on the production of a theory ran somewhat counter to the desire to draw out teacher conceptions of creativity rather than producing another model of creativity to add to the, already extensive, catalogue available in the literature. It was eventually dispensed with in favour of Personal Construct Theory (PCT) because PCT seemed to offer a better way to explore in more depth the understanding of individual teachers about creativity and a way to describe the underlying assumptions and ideas that made up this complex idea for them. However, the mechanics of inductive analysis commonly used in GT (e.g. coding, memos, categories) were used in the eventual research. See Section 3.4.6.1 From conversations to constructs for more information.

3.2.4.4 Personal Construct Theory

Personal Construct Theory (Kelly, 1955) states that our personality and many aspects of how we experience of the world depends on external sensory data interpreted through a system of internal constructs (Bannister and Fransella, 1971). This construct system is a personally unique,

rationalised and organised collection of bipolar constructs, based on previous experiences, which develops throughout life. The construct system not only 'makes sense' of myriad data inputs by relating them to experience-derived understanding but also makes predictions about the likely outcome of actions and decisions. These predictions can then be tested and where they prove to be useful the understanding that generated them is strengthened. Kelly regarded this as analogous to the way a scientist makes predictions based on current understanding, tests them and revises the underlying theory in the light of the results.

> 'All theories of personality make philosophical assumptions about the nature of man and Kelly is no exception. Some theories view man as a mechanical model or a biological model, but Kelly uses a scientific model – man is a scientist. Kelly defines a scientist as one who attempts to predict and control phenomena, and a psychologist as a scientist who attempt to predict and control behaviour, but a scientist who has tended to overlook this same "motive" in his subjects.' (Center, D. B., 1972 p5)

PCT is stated as a formal theory with a single fundamental postulate and 11 corollaries that clarify and extend its meaning (See Sections 3.3.2 and 3.3.3). These have not changed significantly since publication in 1955 and have been applied in a wide variety of fields including organisational development, education, business, marketing, cognitive science and education (Walker, 2007). PCT has spawned an international journal, the Journal of Constructive Psychology, devoted specifically to topics of interest to PCT users, and a number of annual conferences for practitioners. Its predominant focus remains on the study of how people organize, use and change their construct system and how this knowledge can be used in a therapeutic context. Further details of PCT are described in Section 3.3: Personal Construct Theory.

In Section 3.2.4.1: Decision parameters, I listed four broad concerns relating to the choice of an appropriate methodology. These were:

- the study should be highly focussed to allow detailed interaction between the researcher and participants and consequently generate rich, qualitative data
- the data collected should be broadly unstructured by pre-existing theories in order to reflect the perceptions of the participants
- teachers of science should be the focus of, and main contributors to, the research
- the research should be achievable within the time and resources available.

While Action Research and Grounded theory approaches both met some of these criteria PCT is uniquely qualified in that it has a focus on individuals making meaning through a discussion of their underlying perceptions. As Caputi's summary of the work of PCT explains:

> '…personal construct methods are designed to assess how the individual makes sense of the world, yielding a more holistic view of the respondent's meaning system than is afforded by most traditional psychological assessments.' (Caputi, 2012 p 13)

This 'holistic view of the respondent's meaning system', in this case science teachers' understanding of creativity in their classrooms, is precisely what this study is seeking to investigate.

PCT was developed in a therapeutic context and has been most widely applied in a clinical or therapy setting (Walker and Winter, 2007). It has been used to aid the understanding, and treatment of, conditions like schizophrenia (Bannister and Salmon, 1966; Bannister and Fransella, 1966; Lorenzini *et al*. 1989), suicidal thoughts and self-harm (Neimeyer and Winter 2006) and a range of obsessive-compulsive disorders, depression and eating disorders (Winter, 1992). In all of these fields, users of PCT seek to understand and promote personal change rather than simply diagnose and treat. This commitment to understand has been helpful in a variety of psychotherapeutic settings including work on stuttering (Fransella, 1972), bereavement (Neimeyer, 2001) and marital therapy (Kremsdorf, 1985).

In education, PCT has also been used extensively with young people both in and out of school and has informed the supportive work of many educational psychologists with some practitioners developing PCT methods appropriate for children even as young as primary school age (Ravenette, 1999). For example, in a study of 13 junior age children on the special educational needs register Maxwell (2006) used a combination of student-generated drawings and PCT-style conversations (See Section 3.4.4: Conversations) to elicit constructs relevant to how the students viewed their school experience. It is notable that in his paper he devotes a section specifically justifying the decision to ask student about their views (Maxwell, T. 2006, p20). He claims that, by allowing the children to talk he was able to understand far more about how they viewed school and their experiences of it and he suggested that this activity was not merely interesting from a research viewpoint but could actually help to drive school improvement. He makes clear the 'value of listening' in his conclusion.

> 'The value of listening can, as Reid (1987) feels, help pupils to feel included in their school community. To ask is to acknowledge they exist and have a viewpoint, and can help them to be recognized as members of the school.' (Maxwell, 2006 p 25)

In another example of PCT's applicability to research in education, Hardman (2001) described the use of PCT in an 8-week intervention with a Year 10 student, identified as 'Daniel', considered to be at risk of exclusion. She used PCT approaches to help Daniel to explore and understand the underlying constructs he was using to interpret the world around him. These constructs were helping him to formulate his behaviour so, by making them apparent to him, it was possible to help him think more effectively about changing this behaviour where appropriate. She also worked with the teaching staff to help them to uncover their understanding of Daniel's behaviour and their responses to it. Running through all of the intervention was a commitment to listen to the student - a perception that she felt Daniel valued.

> 'Daniel felt somebody had listened to his point of view, which is an important aspect of the EP [Educational Psychologist] role. PCP [Personal Construct Psychology] is an enabling strategy that can allow children to tell their stories. Jackson and Bannister (1988) comment that most behaviour scales assess the adult's perception of a child's behaviour. This is important in the process of unpicking the issues but it gives little detail about the 'meaning ' of the behaviour to the child, or his/her perception of the

behaviour in their worldview. Kelly (1955) suggests that, if you want to know what's wrong with a child, ask them; they might just tell you! ' (Hardman, C. 2001. p50)

Both of these studies illustrate PCT researchers' commitment to listening and understanding. This is particularly relevant for the present study with its stated commitment to listening to teachers. However, PCT is also involved in theory and model creation. In a contribution to the research on autism, Proctor (Proctor, 2001) uses the fundamental postulate and 11 corollaries (See section 3.3.2: PCT: the fundamental postulate and 3.3. 3 PCT: the 11 corollaries) to develop a model of the autism disorder spectrum. Proctor claims that his approach offers real benefits both for therapists working with people on the autistic spectrum, their families and, perhaps most significantly of all, the person themselves. PCT can begin to help them understand their own behaviour, and the behaviour of others, in a rational , rules-based model rather than being simply random. Importantly, it also offers ways to change their constructs and consequently their interactions with the world and others.

'This strength of PCP in focusing on the individual's particular world can help place the client's struggle with autism within a general framework of construct systems and their development.' (Proctor, 2001 p 123)

In Initial Teacher Education (ITE) PCT has also been used with teachers and trainee teachers to explore their ideas of mentoring (Jones, Reid and Bevins, 1997) and the role of the classroom teacher (Brodie, 2011). In the 1997 study, teachers' perceptions of mentoring 20 ITE participants from schools near Manchester were explored and this produced a range of constructs that provided a view of what these mentors regarded as 'good mentoring'. This was valuable not only in that it provided guidance for the development of mentoring systems but also, as the paper notes, because teachers themselves were active contributors lending the conclusions greater authenticity and authority than a purely theoretical study.

'What is new and encouraging in this study is not so much what the teachers are saying … but the fact that it is teachers themselves who are saying it.' (p 260)

Brodie's work (Brodie, 2011) used a similar approach looking at the perception of the role of a classroom teacher amongst a group of undergraduates who had not yet identified as potential teachers (i.e. they were not applying for ITE). PCT-style conversations were held before and after a period spent helping in schools and changes in their understanding of the role of a classroom teacher noted. The participants moved significantly towards a career in teaching as a result of their experience. While this was arguably valuable given the shortage of science teachers the significant point for the purposes of this study issue is that PCT was used effectively to track the perceptions of participants in an educational study and that the insight generated helped them (the participants) to re-consider their positions and make informed changes. From the researcher's perspective the knowledge of how these constructs change over the course of ITE helped to inform future decisions on courses for trainee teachers and the support they needed.

In all of these examples PCT has been used to develop an understanding of participants' understanding which benefits both the researcher and the participant. This makes it particularly

appropriate for this research which seeks not to measure or define creativity but to understand what science teachers understand by the concept of creativity in their own classroom.

PCT is described in more detail in the next section but the key features that make it appropriate for this study are that it:

- focusses on participants and commits to hearing their voice
- has an open, inductive approach to data
- is capable of generating useful insights from relatively small numbers of participants
- has a history of deployment in education to understand people's perceptions and insights

The sections that follow describe Personal Construct Theory in depth, covering its fundamental postulate and the 11 corollaries.

3.3 Personal Construct theory

This section covers the essentials of Personal Construct Theory describing the fundamental postulate and the 11 corollaries.

3.3.1 Development of PCT

3.3.1.1 George Kelly

The originator of Personal Construct Theory (PCT), George Kelly (1905 -1967), was born in Kansas, USA and graduated from Friends University and Park College with degrees in mathematics and physics. His Masters degree from the University of Kansas was in Sociology with his thesis looking at workers' leisure activities. In 1929 he did a BEd at Edinburgh University, Scotland and then returned to the USA to complete a doctoral degree in psychology at the State University of Iowa before working as a psychotherapist in Kansas. This collection of sciences, education and psychology reflects Kelly's wide range of interests and perhaps suggests why, when he eventually published his first book on Personal Construct Theory, it drew on a range of scientific and psychological insights. *The psychology of personal constructs* (Kelly, 1955) was a summary of 20 years of his experience in psychotherapy and grew out of an attempt to provide a handbook of his ideas for his students. The book itself was a collaborative effort involving writing and discussion sessions every Thursday evening for three years between Kelly and his colleagues (Winter, 2013).

3.3.1.2 Constructive alternativism

Kelly described his own underlying philosophical position as 'constructive alternativism' to show how his ideas about personal constructs reflected his wider understanding of the world and the nature of people, reality and free will. He suggested that people are not directly aware of the outside world but only their internal construction of it and that they create this using data from their sense organs and existing understanding of how the external world operates. He called the production of this interpretation of the world construing. If this is the 'constructivist' half of the term the insistence that everyone develops their own, personal, construction provides the sense

of ‘alternativism'. Each person has their own construction system which makes sense to them even if it appears bizarre to others.

This does not mean that everyone’s construction system is equally useful. Someone who suffers from a serious debilitating mental illness has a less useful construction system than someone who is generally recognised as healthy, because their constructions can lead to bizarre or counterproductive construing. A person who hears imaginary voices or suffers from irrational fears has a valid, personal construct system but it is not helping them to navigate the existing world in the way that a healthier, more adaptive construct system may have done. Kelly himself was clear on this issue describing a psychological disorder as ‘any personal construction which is used repeatedly in spite of consistent invalidation’ (Kelly, 1955, p. 831). By this he meant that any person using an existing construct system which was unable to make useful predictions to guide future behaviour (they were constantly ‘invalidated’ by experience) had a psychological disorder. Indeed, PCT has an extensive use as a therapeutic tool to help people revise their constructs into more adaptive and helpful ones (Fransella, 2005; Holland *et al*, 2006).

Kelly recognised that a person’s construct system was only ever a temporary construction and open to constant revision as new data is received and built into their ‘working understanding’ of the world. He regarded this business of testing and building a useful, predictive model of the world around us as the fundamental characteristic of human life.

> ‘Suppose we begin by assuming that the fundamental thing about life is that it goes on. It isn't that something *makes* you go on; the going on *is the thing itself*. It isn't that motives make a man come alert and do things; his alertness is an aspect of his very being.’ (Kelly, 1962, p 85)

This insistence, that a person was not simply responding mechanically to external stimuli but was actively construing data to make sense of the world and formulate appropriate responses based on their existing understanding of how the world operates was contrary to some of the thinking at the time. Bannister and Fransella, two active developers of PCT and its applications, make this point explicitly in the preface to the third edition of their, appropriately titled, book about PCT, *Inquiring Man: the Psychology of Personal Constructs* (1986, Routledge):

> ‘Our preface to the first edition of *Inquiring Man* introduced the book as an attempt to make clear what was singular about Kelly’s theory of personal constructs. That purpose remains and we still strive to ‘emphasise that construct theory sees man not as an infantile savage, nor as a just-cleverer-than-the-average ape, nor as the victim of his biography, but as an inveterate inquirer, self invented and shaped, sometimes wonderfully and sometimes disastrously, by the direction of his enquiries.’ (Preface, p1)

This understanding remains central to PCT to this day - that humans interpret the world around them by reference to an internal, but malleable, construct system that they generate themselves. In this sense, we are all the authors of our own lives.

3.3.1.3 A description of a personality

PCT explores how personalities form and grow, how behaviours are generated from conscious and unconscious decisions and how this knowledge can be used in therapy to help people understand and manage their own motivations more clearly.

PCT identifies two components in the description of a personality: a number of bipolar constructs and the relationships between them. A construct is a bipolar structure with two poles. These poles describe the far ends of a spectrum that exists between them. The poles are not simply opposites but, taken together, provide a description of the understanding a person has about a particular aspect of the world around them. So, a teacher may have a view of what constitutes a 'good lesson' but this is clarified by a complementary view of what they consider a 'bad lesson'. The good lesson pole may include items such as active student involvement, clear learning objectives and a sense of achievement whereas the 'bad lesson' pole is characterised by student passivity, a confusion about the purpose of the lesson and a sense of failure.

A teacher's construct of a lesson will be only one of a large number of interrelated constructs they use everyday. The relationships between these constructs modify their action and interpretation to provide a construct system that allows the teacher to predict likely outcomes of a particular behaviour by recognising replications from their previous experience. A replication is a similar experience or set of experiences that share some of the same characteristics rather than a perfect match. Effectively the teacher interprets incoming data with reference to previous experience, recorded in their construct system. Once suitable replications have been found, the construct system can make predictions of what is likely to happen if they engage in a particular behaviour (possibly behaviours familiar from previous experiences) and so guide subsequent action.

The fundamental postulate and the 11 corollaries describe the structures and mechanisms that drive the ongoing development of a personality rather than the content that makes up that personality. Two people with very different personalities can both be described with reference to PCT but the constructs they use, the relationships between them and the ease with which the construct system can be modified and developed in novel or threatening situations will vary considerably. Given the complexity of a whole personality it is probably impossible to develop a detailed, predictive model of a specific person. Also, since the construct system itself is inherently dynamic the understanding may be transient - merely beginning to understand one's construct system may produce changes in that system. Given this complexity, a personality description surfaced by PCT will inevitably be incomplete and temporary. However, this does not mean it is not useful. Its incompleteness allows focus on a particular aspect and the temporary nature provides opportunities for growth and development. This is the basis of PCT as a therapeutic tool where change is actively promoted.

This research used PCT to explore and understand a single aspect of a teacher: the portion of their construct system that relates to creativity in their science lessons.

3.3.2 Personal Construct Theory - the fundamental postulate

Personal Construct Theory was described in formal terms through a fundamental postulate or claim supported by 11 corollaries or clarifications which extended and developed the fundamental postulate. The sections that follow illustrates the theory by reference to these as they apply to a trainee teacher's construct of a 'science lesson'.

PCT's fundamental postulate is that : 'A person's processes are psychologically channelized by the ways in which they anticipate events.'. As Bannister and Fransella (1986) explain in their book, *Inquiring Man*.

> 'This implies many things. It implies that you are not reacting to the past so much as reaching out for the future; it implies that you check how much sense you have made of the world by seeing how well that 'sense' enables you to anticipate it; it implies that your personality is the way you go about making sense of the world.' (p7)

The use of 'channelize' does not imply a mechanistic or controlling link between cause A and effect B. Kelly was saying that people have a system for predicting what is likely to happen, based on their experience and the model they have of the way the world works in their heads. Once they have generated a prediction of the likely implications of a range of possible actions they respond appropriately (their processes are channelized) and if the outcome is pleasing (their prediction turns out to be valid) that channel is deepened. An analogy might be of students wanting to get from one side of a pristine university lawn to the other. Despite constant warning not to walk on the grass they predict that a straight diagonal path across the square will get them across more quickly than the route around the edge with limited chance of censure from university authorities. As time goes on the lawn is worn away to give a muddy brown path which further encourages more people to take that route across the quad. The path is the 'channel' but the process of predicting the shorter route and that any censure is unlikely or tolerable is the 'channelizing'.

Personal Construct Theory went on to suggest that the mechanism generating this channelising involved a system of personal constructs. This system provides a short cut to appropriate behaviours and understandings based on recognising a particular situation or event as being similar in some ways to others which have been built into their construct system. Kelly called these found similarities 'replications' to distinguish them from identical matches.

3.3.3 Personal Construct Theory - the 11 corollaries

In addition to the fundamental postulate PCT is clarified by 11 corollaries. The 11 corollaries describe the mechanisms and rules of the system that find these 'replications' and manage the 'constructs' to 'channelize processes'. These corollaries are listed in Table 3.1 and explored in more detail in the pages that follow. Kelly did not imply any hierarchy in the listing of the corollaries.

Table 3.1: The 11 corollaries of Personal Construct Theory

The 11 corollaries of Personal Construct Theory	
1	The construction corollary: a person anticipates events by construing their replications.
2	The experience corollary: a person's construction system varies as they successively construe the replication of events.
3	The dichotomy corollary: a person's construction system is composed of a finite number of dichotomous constructs.
4	The organisation corollary: each person characteristically evolves, for their convenience in anticipating events, a construction system embracing ordinal relationships between constructs.
5	The range corollary: a construct is convenient for the anticipation of a finite range of events only.
6	The modulation corollary: the variation in a person's construction system is limited by the permeability of the constructs within whose range of convenience the variants lie.
7	The choice corollary: a person chooses that alternative in a dichotomized construct through which they anticipate the greater possibility for extension and definition of their system.
8	The individuality corollary: persons differ from each other in their construction of events.
9	The commonality corollary: to the extent that one person employs a construction of experience which is similar to that employed by another, their psychological processes are similar to that person.
10	The fragmentation corollary: a person may successively employ a variety of construction subsystems which are inferentially incompatible with each other.
11	The sociality corollary: to the extent that one person construes the construction processes of another, they may play a role in a social process involving the other person.

3.3.3.1 The construction corollary

A person anticipates events by construing their replications.

Since the range and amount of incoming data for any human being is too large to analyse every single datum independently, a more economical system is required to make sense of the events in real time. Kelly proposed that we create some abstraction from patterns of data and these abstractions help to optimise future processing. He called the abstractions constructs. The construct 'lesson' for a trainee science teacher could typically involve a single adult in the class (the teacher) and a group of 30 students. There would probably be a variety of activities including the teacher and student talk, practical work with laboratory equipment, reading textbooks, writing in notebooks and all of these activities would be designed to support learning of a particular

topic. The construct could also include details about expected behaviour of students, the length of time it will last and even the venue. This construct 'lesson' will be personal to our trainee teacher and be based on their previous experience at school as a student, observations of experienced teachers at work and potentially information from lectures and tutorials at college. The construct 'lesson' can be applied, with some modifications, in a range of contexts so if the science trainee was to go into a French or a Geography lesson they might expect to see some of the characteristics of the science lesson but probably not the use of laboratory glassware. Both teachers and students can predict the characteristics of a 'lesson' and behave in a way that makes sense to them for a lesson. The process of matching incoming data ('I'm in a room with 30 students looking at me, a set of laboratory equipment and a desire to communicate the properties of Group 1 metals') with appropriate constructs ('looks like a chemistry lesson') is called construing and involves recognising matches between data and previous experiences distilled in relevant constructs.

The construct 'lesson' in the previous example described a relatively straightforward event at a particular time and place but other constructs can be more sophisticated and abstract. 'Fairness' is a construct familiar to even the youngest child arguing with their parent while 'beauty', as applied to a mathematical equation, may be available only to a smaller number of people with requisite domain knowledge. In this particular study of teacher understanding of creativity the construct 'optionality' appears regularly. When teachers construe incoming data to recognise 'optionality' they expect that they will be more creative in instances where they have the option of making choices. Conversely, if their range of available options is limited they will construe a situation where creativity will be limited and respond appropriately for that situation.

3.3.3.2 The experience corollary

> A person's construction system varies as they successively construe the replication of events.

Individual constructs are plastic to some degree and the system of interacting constructs is even less fixed. Experience allows people to revise their constructs so that the next time they use them the predictions are more reliable. If the construct has produced a prediction that worked well it may be strengthened and gain more weight in the construct system. If the prediction was not borne out by experience the construct may be revised or, in some circumstances, completely rejected. This is analogous to a scientist developing a theory or hypothesis by making and testing predictions based on the logic of the underlying theory.

A student teacher may have a construct for a 'good lesson' in which students do as they are told. As they develop as a teacher they may revise this construct to emphasise student learning more strongly than compliant behaviour and recognise classes that may be more challenging in terms of behaviour as 'good' because they produce thoughtful work of a high standard. Their construct 'good lesson' may change - with a consequent change in the contrast pole, a 'bad lesson'. Since the construct system will be used to predict events and guide behaviours this may change the

way the teacher approaches all of their classes changing their behaviours to encourage more student learning rather than simply classroom control.

3.3.3.3 The dichotomy corollary

> A person's construction system is composed of a finite number of dichotomous constructs.

Kelly stressed that constructs were different to concepts in that constructs were dichotomous. For the student teacher mentioned above the 'good lesson' is part of a construct alongside the notion of a 'bad lesson'. The construct has two ends and the system distinguishes between these when construing incoming data. However, other constructs may also be relevant here, perhaps one related to the activity in the lesson. In a 'practical' lesson the students will engage in some activity that is not paper-bound (e.g. laboratory work, a fieldwork exercise in biology) whereas in a 'non-practical' lesson the work will be paper-based (e.g. working from textbooks, writing an essay). The 'good-bad' and the 'practical-non-practical' constructs form part of the person's construct system described in the organisation corollary.

3.3.3.4 The organisation corollary

> Each person characteristically evolves, for their convenience in anticipating events, a construction system embracing ordinal relationships between constructs.

Personal constructs do not operate in isolation. This organisation makes the system flexible and effective while preventing the number of constructs spiralling up through increasing levels of specificity into infinity. The construction system guides (channelizes) responses in real time and too extensive a collection of constructs would become too unwieldy to manage.

They are connected to each other and are used in combination to guide understanding and responses. Subordinate constructs are ranked below other constructs. So, if construct B is subordinate to construct A then, in taxonomic subordination, the full range of construct B exists at one end of construct A. Our imaginary trainee teacher might describe a lesson where students are learning as a 'good lesson' while the other end of the dichotomy is the 'bad lesson' where students are not learning. Figure 3.2. shows how different construct fit under the 'good lesson' end. This construct contrasts 'practical work' (which includes manipulation of laboratory equipment and chemicals) with paper-based work (which involves a paper-based output). Both of these (practical and non-practical) could be examples of good lessons since they are subordinate to that end of the lesson construct. Another construct looking at the nature of the practical work, comparing open and closed inquiry, fits, in turn, under practical work. Note that all the constructs are developed from personal experience and their arrangement in the construct system is also a matter of personal experience.

An alternative form of subordination occurs when stacks of constructs are linked with their poles aligned. This is termed constellation. This form of subordination tends to be more common in scientific work where the the links within a personal construct system between constructs are very tight. Looking at classification of animals for example in Figure 3.3 runs in parallel to the mammals-reptiles construct. So, all mammals are furry while all reptiles are scaley.

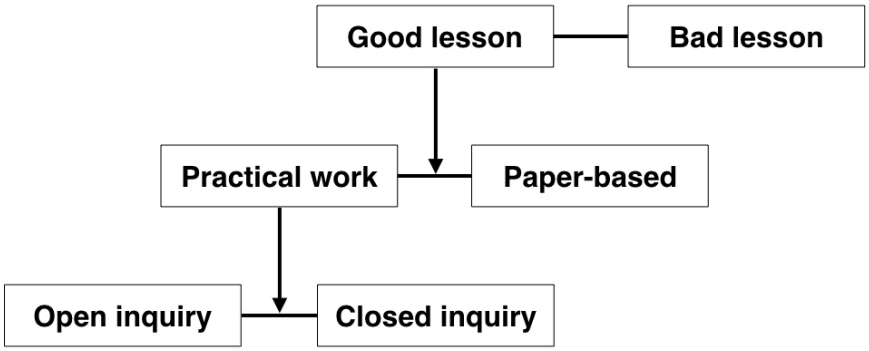

Figure 3.2: Subordinate constructs for the lessons construct system

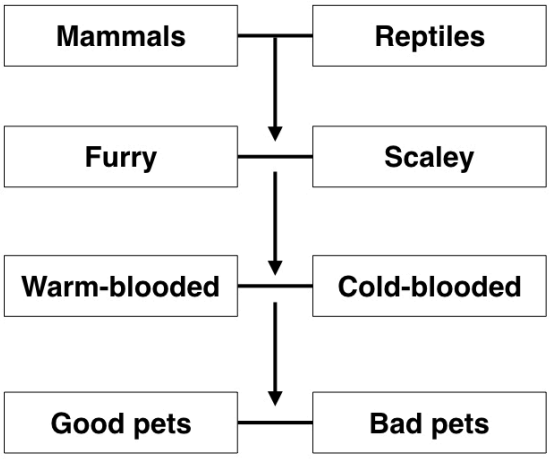

Figure 3.3: A constellation of constructs

Logical thinking makes use of these tight linkages often expressed in a general form as ‘IF this THEN that’. So the construct of particle size (fine-coarse) can be linked to the rate of reaction (rapid - slow) and the construct system used when considering dissolving marble in hydrochloric acid. IF the solid is finely powdered THEN it will dissolve more rapidly in a given liquid than a coarsely-ground powder of the same substance would in the same liquid given other conditions (temperature, pressure etc.) are constant. Much of science education concerns itself with organising and strengthening these linked constructs as they are often usefully predictive. People with a clear ‘metal-nonmetal’ construct who also know that iron is a metal can predict a number of its physical and chemical properties because malleability, ductility and being good conductors of electricity and heat are linked in a constellation below ‘metal’.

However, the constructs employed and the construct system in which they are embedded are personal and may contain a mixture of standard, agreed interpretations and a number of more personal, possibly bizarre, understandings of the area in question. In the animals construct system illustrated the first three constructs are objectively demonstrable (mammals are furry and warm-blooded) while the ‘good pets-bad pets’ construct that is also part of the system is simply a personal opinion. Some people may prefer a gecko to a kitten while others would rather have a mouse than a snake. The particular danger with these sorts of constellatory construct subordinations is that they not only channelize thinking and understanding but also help to form interpretations of any new data making it more difficult to modify erroneous constructs.

Whether constructs are linked in superordinate-subodinate rankings or as constellations the strengths of the links will affect the ease with which these systems can be modified. Tight links are stable whereas looser ones are more open to change. To illustrate with a, perhaps, trivial example: flared trousers and flowery shirts may have been clearly linked to the fashionable end of the ‘cool-square’ construct in 1970. Since then the linkage will have changed considerably although for some people flowery shirts will always remain ‘cool’. Constructs, and the linkages between them, are construed and modified personally.

3.3.3.5 The range corollary

A construct is convenient for the anticipation of a finite range of events only.

A single construct has a range of convenience where it can usefully be applied. For example, one person may find the gender construct (male-female) useful in a number contexts, e.g. when searching for a life partner, possibly with some animals (do not walk into a field of bulls even though a field of cows may be no problem) and even some plants (certain fruiting plants come in male and female forms with only the female plants producing fruit). However, the same person may not see an immediate use for male-female when considering insects. A celibate researcher into Lepidoptera working on an isolated pacific atoll would use the construct on a regular basis with regard to insects but show little interest in seeking a life partner of appropriate gender and would have no reason to come across a field of cattle. Even within the range of convenience a construct may have a particular area where it is maximally useful. This is called the focus of convenience and for urban citizens with limited access to gardens or the countryside the

construct focus of convenience would probably be firmly on sorting other human urban dwellers into male and female types.

Some constructs have a wide range of convenience and can be easily stretched to fit new contexts. Male-female has a clear focus of convenience on sex and gender in humans (even if exact definitions of the construct depend on personal perceptions), potentially reaching to higher animals and even further to include plugs and sockets used in a variety of electronic devices. So, an electronic supplier's catalogue could list 'male-female USB connectors' or 'male audio plugs' with complete confidence that their readers will be able to stretch their male-female construct to encompass these apparently genderless objects. In the same catalogue, more impermeable constructs will appear. Lights may be described as LEDs or incandescent bulbs. The distinction is clear but offers little utility beyond this specific instance, it is not easy to see how the distinction between 'LED light'-like and 'incandescent bulb'-like would be useful in a person's wider life. Constructs that can be usefully applied across a wide range are called comprehensive whereas constructs that are very technical with a small range of convenience are known as incidental. Even though a construct may be incidental it may still be highly significant when used, for example the construct conscious-unconscious may be very specific and incidental but when applied by an anaesthetist in a surgical procedure its correct usage is critical for the patient on the operating table.

3.3.3.6 The modulation corollary

> The variation in a person's construction system is limited by the permeability of the constructs within whose range of convenience the variants lie.

As people age they have more experiences which means that they must deal with data with consequent revisions of their construction of the world. They could fit these new data items into existing constructs or develop new constructs. Constructs that are open to new items of data are described as permeable, in effect their range of convenience expands as the person construes more meaning from a wider and wider range of potential data items. Our trainee teacher might initially have a very clear construct about the role of the teacher compared with the students which emphasises the teacher lecturing from the front of the class and the students being relatively passive and certainly attentive. However, in the first teaching practice, the trainee was exposed to a very different approach to teaching with students actively questioning the teacher and each other through organised discussion. If the trainee's construct about the role of the teacher is permeable this surprising data could be integrated and the construct system would become both more resilient and better able to produce useful predictions - observable as a change in the trainee's understanding of the role of a teacher and the behaviour appropriate in a lesson. However, if the constructs are impermeable new data creates confusion and conflict. A person with impermeable constructs might find it difficult to make sense of the changing world and may force new experiences into old constructs even if the fit is poor. This does not mean that permeable constructs are 'good' and impermeable 'bad', each has its place in healthy construct systems and their value depends on their usefulness in any given circumstance.

Permeability can appear to be the same as the re-applying constructs in a wider range of convenience as described in the range corollary. However, they differ in that permeability is a measure of how the construct itself can change while its range of convenience is a measure of how widely it can be applied in its current form.

PCT regards the loosening and tightening of constructs (changing the degree of permeability) as a source of creativity. As constructs are applied more loosely, *i.e.* with greater permeability, unexpected parallels or analogies or new ways to construe events may appear which, in turn, work well (i.e. provide useful predictions for behaviours). This improved efficacy validates the construct's extended range of convenience and may lead to a reduction in permeability to protect the new understanding. This cycle of loosening and tightening can be repeated many times to develop new ways to construe the world. This is described in more detail in Section 3.3.4: PCT and creativity

3.3.3.7 The choice corollary

> A person chooses that alternative in a dichotomized construct through which they anticipate the greater possibility for extension and definition of their system.

When faced with incoming data they are construed by assigning them to one or the other end of a range of constructs. Kelly claimed that this is largely done unconsciously but not randomly: the pole that is selected is the one that appears most likely to lead to extension or definition the system. Extension increases the scope of the construct system allowing it to be applied in novel situations, effectively the utility (range of convenience) of the construct employed is increased. Definition describes the opposite process: honing the construct to produce an increasingly precise description. Both tend to increase the predictive power of the system either through increasing the range of data the construct can handle (extension) or by specifying in more detail exactly where it can be applied (definition) and the exact nature of the predictions made possible.

3.3.3.8 The individuality corollary

> Persons differ from each other in their construction of events.

In a theory called Personal Construct Theory it seems unnecessary to state that everyone's construct system is personal and hence different from the systems in the individuals around them to a greater or lesser extent. This explains how people can respond to identical data in very different ways, PCT suggests that they even 'see' the data differently as they construe the world around them in order understand it and make useful predictions. Even if, miraculously, two individuals could exist that had the same construct system, even a few day's exposure to the real world would tend to move them apart. An apparently minor difference in experience or perception could lead to a slightly different construing which, in turn, could lead to a slightly different perception of future data which drives the construction systems further apart.

3.3.3.9 The commonality corollary

> To the extent the one person employs a construction of experience which is similar to that employed by another, their psychological processes are similar to that person.

Despite every person being different, as described by the individuality corollary, it is possible to share similar ways to construe events. If people were entirely different in their perceptions of the world and each other and construed every event in entirely idiosyncratic ways they would not be able to communicate or understand each other at all. The more similar their construction systems are the more similar they are likely to appear. Kelly claims that since our 'personality' is the outworking of our construct system so people with similar construct systems operating in similar ways will have similar personalities.

However, rather than seeking to distance themselves from others, as the individuality corollary might suggest, Kelly claimed that people spend a lot of time looking for validation of their construct systems. He claims that they are, in effect, looking for people who have similar construct systems - who 'think the same way'. Initially they might look in their own culture or with people who share their experiences and yet find, perhaps, that they feel most comfortable with people from apparently very different upbringings. Somehow, people perceive shared aspects in construct system in others - even if they were produced by different events in different circumstances.

3.3.3.10 The fragmentation corollary

> A person may successively employ a variety of construction subsystems which are inferentially incompatible with each other.

Humans play a number of roles that require the use of a number of different construct systems to navigate these. So, an expert in one field might be required to control and drive a meeting taking decisions and managing dissent ruthlessly to achieve a desired goal in a given time. In a different setting the same person may be a hapless student trying to learn new skills and approaches to a problem from a much more skilled guru. The construct systems employed in each scenario will be different and apparently contradictory as the person makes sense of their different roles and responsibilities.

3.3.3.11 The sociality corollary

> To the extent that one person construes the construction processes of another, they may play a role in a social process involving the other person.

The commonality corollary explains how people can be similar to each other if they have similar construct systems. It is natural to expect that these people will show a degree of affinity. The sociality corollary describes how people who are very different and have different construct systems can still have a good relationship. If person A can understand how person B thinks (if A can construe B's construct system) then A can have a positive relationship with B even though they might disagree on almost every issue and behave in very different ways. Negotiators and

arbitrators need to be particularly good at construing the working of others' construct systems both to understand why they are making certain claims or demands and to predict how they might respond to particular proposals or actions.

3.3.4 PCT and the Creativity Cycle

PCT explains creativity in terms of a cycle of loosened and tightened construing. In tight construing new data inputs are assigned tightly to one or the other end of a construct. So, a person may be 'good' or 'bad' rather like a pantomime heroine or villain. A looser construing might place a person along the spectrum from good to bad rather like the sympathetic villains in more modern dramas - the audience may know that he's a villain but there are some extenuating circumstances and they see him as a more nuanced character.

Insofar as a cycle ever begins, the creativity cycle begins when construing certain aspects of experience is loosened. This allows new insights to appear. If a datum item *x* is not construed as entirely this or entirely that then maybe an alternative way forward or relationship becomes apparent - possibly with data object *y* which forms a loose replication. If this produces a useful prediction which is validated by experience the constructs are modified accordingly to match this new situation. The tightened and validated constructs then 'complete' the creativity cycle. Effectively new insights and ideas are created and then embedded in the more developed construct system.

A good example is provided by toy building blocks. The construct 'brick' has an appropriate range of convenience here since, although toy bricks made be made of brightly-coloured plastic rather than fired clay and clip together rather than being stuck together with mortar, they share a sense of 'brickness' as opposed to other toys, e.g toy cars. This 'brickness' is a useful way to construe them as objects to build walls, houses, towers and so on. One of the characteristics of bricks is that they do not have wheels attached and toy cars do. However, if the construction is loosened slightly an object that has some elements of 'brickness' to it and some aspects of toy cars to it (wheels) could be conceived. A plastic brick with wheels attached opens up a range of other possible uses for the building block set and so the new ways of construing is validated and the constructs are tightened.

In science education a similar approach is used when developing learning activities for students. Pteranodons were giant flying reptiles from the late Cretaceous period with large wings made of leather-like skin stretched over bones. The exact mechanics of their flight remains open to debate since the musculature revealed by fossils does not support the flapping of wings typical of modern birds. In a simple scientific inquiry activity developed for use in schools a piece of stiff card was used to model the wing and a paper clip the neck of the Pteranodon. A blob of modelling clay acted as the head. Clearly the card and paperclip model was not a Pteranodon and it was not even an accurate scale model: the wings were not shaped like Pteranodon wings, the body and legs were absent and the wings could not flap or flex. However, by construing the basic model loosely and ascribing a sense of 'flying Pteranodon' to it a useful system was created

to explore what might happen if the ‘neck’ (the paperclip) is lengthened relative to the body or the mass of the ‘head’ (the blob of modelling clay) was increased. Insights generated from controlled tests on the flying model could then be related to a real Pteranodon to create knowledge about some aspects of the reptile’s locomotion. As constructs to do with flight stability, neck length, head mass etc. are created and formalised these can, in turn, be applied more tightly to Pteranodon bodies as revealed by fossil remains. This simple activity required students to construe the card model loosely at one point but then also construe logical IF-THEN constructs tightly (e.g. IF the neck length is between *x* and *y* % of body length THEN the flight is *z*% more stable which will have this effect on the flight of a real Pteranodon).

In both of the examples above, new insights were created - a characteristic of creativity. Similarly Einstein’s famous thought experiments were exercises in creativity made possible by loosening of existing constructs. So, imaging a surfer riding on the front of a wave of light was a nonsense in terms of many of the constructs that apply to surfers or light waves. However, loosening these constructs slightly, while retaining aspects of them, allowed Einstein to explore ideas and possibilities that were beyond any possible equipment available at the time. Once the logical outcome of these ‘experiments’ were codified and tested the constructs could be re-formulated and enhanced to take into account these surprising results.

3.4 Eliciting constructs

To describe a construct system it is necessary to identify and describe the relevant constructs and how they are related to each other. Kelly developed a number of methods to do this and these are described in this section.

3.4.1 Levels of awareness

PCT does not claim constructs are subconscious or its workings secret. Indeed, the process of construing must lead to the generation of predictions by the construct system which guide observable actions. However, this does not mean we are always consciously aware of this process or the shifting of construct meanings and relationships.

PCT claims that people may be aware of the constructs they have used at different levels. For example, when reading or viewing something a person may have felt angry or disturbed but not be able to explain exactly why that text or that image caused such a response. Their awareness of their constructs in this context is below conscious understanding. In other situations they may be able to explain their feelings and actions quite clearly by reference to their constructs of ‘right’ and ‘wrong’ or ‘attractive’ and ‘ugly’ even if they did not use the word ‘construct’ but instead refer to ‘ideas’ or ‘beliefs’. Constructs with names are generally easier to elicit and discuss than constructs that do not have readily-accepted labels. ‘Beauty’ may be in the eye of the beholder but it is easy to talk about it as a pole of a construct with ‘ugliness’ because the verbal tags ‘beauty’ and ‘ugly’ label the poles conveniently for discussion.

Since constructs are applied routinely without the need for conscious involvement simply asking people to describe their constructs is unlikely to generate a complete catalogue or even accurate accounts of the construct identified. Kelly's constructs are also potentially complex and many people might find difficult it to understand or describe them effectively. Since constructs are primarily used to differentiate or sort, Kelly developed a technique that would allow him to observe this sorting in action. 90% of personal construct research and therapy still uses a derivative of this sorting approach (Neimeyer et al. 1990).

3.4.2 Elements

In an informal interview situation, Kelly called them conversations rather than interviews, data items, which Kelly called elements, were provided to the person and they then sorted these into 'similar elements' and 'different elements'. Since Kelly worked in a therapeutic setting and developed his theory to support his work with his patients he would agree elements with his individual clients prior to construct elicitation. This remains common amongst therapists using PCT. However, the choices were not completely open. Participants would be asked to write down on cards the names of people who were significant to them, typically these could be friends, parents, siblings, bosses, enemies or dependants. For each client, while the elements (the individual people) would be different, typical roles would often appear e.g. 'parent', 'child', 'boss'.

Elements can be people, events or objects that are significant in the field of interest and meaningful to the participant(s). The number of elements for a conversation was not critical, provided that it was manageable, and usually varied between 8 and 15. Elements could be provided by the researcher, elicited from the participant or a combination of the two. The format of the elements was similarly open (audio clips, video clips, printed cards). In a sense, the elements were simply stepping stones to elicit a person's constructs.

In a study of changing Turkish student teachers attitudes (Sendan and Roberts, 1998) student teachers were asked to supply nine elements from their own experience. These elements were to be the names of teachers of English language who were known to the Turkish students and fitted into these classes: three effective teachers, three average or typical teachers and three ineffective teachers. To these nine were added two other elements: 'my current self' and 'my ideal self' giving 11 elements in total which could be used to elicit constructs. Here two elements (my current self, ideal self) were constant throughout all research participants while nine (the relevant teachers' names) were varied - some may have been common and some unique to individuals. Since the project was looking at student teachers' personal theories about teaching and their development throughout training the same elements were used with each individual on five occasions throughout training. During the course, the constructs produced varied across the participants, as predicted by PCT, even though the elements were constant. This study also used Repertory Grid Technique to show the linkage between all elements and the constructs and could demonstrate a shift in how teacher self-perceptions and their constructs of effective teachers changed over the course of the study (15 months). Interestingly, while the constructs (the

'content' of their construct system) changed somewhat, most of the changes related to the relationships between them (the structure of their construct system).

An alternative approach provides elements. The elements must still be significant and meaningful to the participants with the added requirement that the participants must have some shared understanding of the elements (since they did not create them individually). Given these caveats, using provided elements does not appear to reduce the creation of authentic constructs. For example, in another large scale study into student and teacher perceptions of the English Language Teaching curriculum, quoted in Roberts (1999), elements were provided for all participants. 45 students were involved in this study and the use of common elements allowed comparison amongst the constructs produced. One aspect of the study provided school subjects (e.g. English, mathematics, science) as elements and explored how students construed their relationships to these subjects. In a parallel study the elements were short video clips of teaching techniques (e.g. teacher explains grammar, choral repetition) and student-centred activities (e.g. students working pairs or groups).

In a study conducted by Kreber *et al* (2003) both the elements and the constructs were supplied to participants. This study looked at using PCT as away to assess student learning in undergraduate science courses. 43 instructors were asked to produce a list of the concepts they expected their students to master in the coming course (these became the 'constructs') and a list of topic content they would cover to allow their students to construct these concepts. These topic areas were considered analogous to 'elements'. Students were asked to select constructs that they would use to understand the elements. Where the constructs matched those supplied by the lecturers it was suggested that students had achieved the learning the lecturers had intended.

3.4.3 Sorting techniques

Once suitable elements have been selected they must be sorted to allow recognition of the constructs in use. Sorting exercises used to elicit constructs require the person to differentiate between elements in a formal manner. In a dyadic technique two elements are selected from the pool of elements because they are similar in some way. The person is then asked to explain why they are 'the same' and this becomes the emergent pole of the construct. The contrast pole is produced by asking the person to create it as the opposite to the emergent pole. For example, in a study of a fictitious teacher's understanding of teaching activities they may pick lectures and watching a television documentary from the elements and explain that they are similar because the students are passive in both these activities. The emergent pole here would be 'passivity'. The contrast pole, generated without reference to the elements, would be 'active'. Exactly what constituted 'active' would not be clarified in this instance.

In triadic sorting the person selects two elements from the pool that are similar in some way and a third that is different. The first pair form the emergent pole and the single different element stands for the contrast pole. Note that in the triadic method the contrast pole is 'different' not 'opposite'

because it is created based on the characteristic of the single 'different' element rather than being simply the opposite to a pair of similar cards as in dyadic sorting.

Returning to our imaginary teacher, lectures and watching a television documentary were selected as the similar pair but small group discussion was chosen from the available elements as the different one. When further questioned, the teacher explained that, during lectures and watching a television documentary, students were often bored and retained little of the material covered whereas in small group discussion the students were engaged and tended to develop deeper understanding of the topic. This provides a richer picture of the two ends of the construct and indicates connections with other constructs - in this case to do with learning and retention of learning. With triadic sorting both ends of the pole are described and explored and the distinction between them is more in terms of 'alternatives', which may include 'opposites' but are not limited to them.

In a review of the different possible sorting methods Caputi and Reddy (2010) found that:

> 'The triadic method of elicitation seems to produce constructs that are less functionally independent, more meaningful in that they are better able to discriminate amongst elements. The method generally elicits construct sets that are more cognitively complex.' (p261)

3.4.4 Conversations

Kelly described the elicitation discussion as a 'conversation' not an 'interview' (Kelly, 1955). However, this is not to suggest that the conversation is akin to sharing opinions about the latest soccer results with a few friends over a pint or two. The conversation is focussed on a particular purpose, the elicitation of constructs, and the responsibility for maintaining this focus rests predominantly with the researcher. In many ways this is similar to, but not the same as, a semi-structured interview (Kvale, 2011).

> 'A semi-structured life-world interview attempts to understand themes of the lived daily world from the subjects' own perspectives. This interview seeks to obtain descriptions of the interviewees' lived world with respect to interpretation of the meaning of the described phenomena. *It comes close to an everyday conversation*, but as a professional interview it has a purpose and it involves a specific approach and technique; it is semi-structured – *it is neither an open everyday conversation nor a closed questionnaire*.' (Kvale, 2011 p 121 my emphasis)

The 'themes of the lived daily world from the subjects' own perspective' is equivalent to the personal constructs that will be elicited during the conversation and subsequent analysis.

Kelly's use of the word 'conversation' rather than 'interview' is perhaps designed to make a point that, while the researcher bears considerable responsibility for the conduct of the interview (timing, tone), it is the subject of the interview that supplies the content (their selection of elements leading to the elicited personal constructs). Viewed in this way, PCT's conversations are a type of semi-structured interview using specific protocols (e.g. triadic grouping of elements) to generate discussion and a particular method of analysis (elicitation of constructs). To the

researcher, engaging in a PCT conversations requires similar skills to engaging in a semi-structured interview.

However, PCT conversations are not a simple series of preset sequence of questions developed by the researcher and delivered respectfully in an engaging manner. The locus of control resides predominantly with the person who is sorting the elements according to their personal constructs although the researcher may sensitively probe and gently direct the conversation back to the field of interest if it threatens to diverge into other areas. A measure of 'directiveness' in interviews (particularly semi-structured approaches) is provided by Whyte (1982) who produced a scale with six levels where a score of six is considered most directive.

1 Making encouraging noises.

2 Reflecting on remarks made by the informant.

3 Probing on the last remark made by the informant.

4 Probing an idea preceding the last remark by the informant.

5 Probing an idea expressed earlier in the interview.

6 Introducing a new topic.

A skilled researcher using PCT will use most of these approaches sensitively although predominantly selecting from the lower levels in order to allow the participant to retain control - as, typically, would a researcher using a semi-structured interview approach. Where new topics are introduced (for example when a new triad of elements is selected) the topic is introduced by the informant who has the ultimate right to select any three elements form the pool available.

This compromise between complete openness to the informant's musings and gentle guidance towards the topic under consideration, in this instance the teacher's understanding of creativity in their lessons, is not easily achieved being, as it is, further compromised by the power differential between the researcher and subject. The researcher has requested the interview (for their own purposes), supplied the initial elements (to focus attention on the topic of interest to the researcher) and will provide an initial analysis of what was said. In relation to semi-structured interviews, Kvale emphasises the role of the interviewer in terms of reducing the power differential and ensuring the interviewed has the power to object to the process or product of the interview when he claims:

> 'Validation rests on the quality of the researcher's craftsmanship throughout an investigation, continually checking, questioning and theoretically interpreting the findings.' (Kvale, 20011 p 126)

While his comment here is specifically about validation it includes the idea that the conduct of the interview (the researcher's 'craftsmanship') should be such that the interviewee feels that they can be honest and forthright in their contributions (prior to, and including, the analysis which may be constructed by the interviewer). The same observation also applies to a researcher conducting a PCT conversation.

A number of other strategies can also be used to minimise the power differential between participants in a PCT conversation. Having the conversation at a site convenient to the subject

rather than the researcher has been shown to help - the subject is on ‘home ground’. (Elwood and Martin, 2000). A clear statement of the purpose and duration of the conversation also helps along with an assurance that the person can withdraw from the conversation at any time. A typical conversation can last from 30 minutes to an hour so it is important to maintain motivation in the subject (Patton, 1980) and potentially offer a chance to break if appropriate. Many PCT conversations are recorded and transcribed for later analysis and permission must be sought for this before the conversation begins. Ultimately, the purpose of the conversation is not a secret and the researcher is not looking for ‘correct’ answers or trying to uncover ‘shocking revelations’ which may embarrass the person involved.

In some conversations the constructs are agreed at the time, for example, in the study of student teacher’s constructs about their pupils (Touw, Meijer and Wubbels, 2015). This allows the participants to elicit the constructs in collaboration and respondent validation is provided at the same time: the constructs are agreed by both parties. In other studies the conversation can be recorded and transcribed for analysis later, for example in a study of sub-Saharan unaccompanied asylum seekers and refugee youth constructs concerning their social situation once in the UK (Amalie, O'Toole , Corcoran and Todd, 2017). In both instances it is crucial that the constructs are elicited from the data rather than the data items classified into pre-existing constructs. While there may be similarities in the constructs that different people have and use in particular circumstances Kelly’s central belief in constructive alternativism means that a person’s construct are personal and potentially unique.

This approach is fundamentally different to the work of a plant ecologist which uses pre-set ‘themes’ (in this case species descriptions) that the data must fit into. So, in an ecological investigation, a researcher may classify the species present in an area by reference to specific types defined externally to the system. Thus, a plant ecologist will recognise a field of dandelions as members of the species *Taraxacum officinale* because a description of the archetypal *T. officinale* exists prior to the ecologist putting their boots on to venture into the field. When a researcher elicits constructs in a PCT conversation, or by analysis of the recordings of that conversation, no constructs exist in the researcher’s mind until the data has been explored. There is no catalogue to check potential constructs against (unlike the dandelions) to look for matches. This means the data (the conversation) must be analysed inductively and be centred on the data immediately in front of the researcher. The significance of induction is discussed in Section 3.4.5.1 which follows.

In this particular study all subjects were volunteers, they were interviewed at their convenience in their place of work, were informed that they could withdraw at any time before, during or after the conversation and retained final say on whether the constructs elicited were good reflections of their position - which they confirmed in the second conversation after they had had time to review the transcript and the constructs proposed (See Section 4.5.1). The use of a pilot study also contributed to development of the researcher’s craftsmanship as did, in this instance, the use of the Storyline method to suggest initial elements and the researcher’s other previous experience with qualitative research (Bevins and Price, 2014).

In many ways the lived experience, for both researcher and participants, of a Kellian 'conversation' and a 'semi-structured interview' will be similar. Kelly's conversations are a particular form of semi-structured interview where the structure is provided by a combination of the elements and the gentle guidance of the researcher. Ultimately, the output must reflect the understanding of the teacher rather than the preconceptions of creativity supplied by existing research data or the researcher's personal bias. Encouragingly when the teachers involved in the current study were asked if the elicited constructs were a good description of their understandings they agreed to all proposed constructs with a single small change in one of the 46 constructs produced (the word 'rare' was changed into 'unusual'). All the teachers also claimed they had enjoyed the process at the end of the conversation and agreed to be involved in any future work in this area.

3.4.5. Analysis of conversations

3.4.5.1 Induction, deduction and abduction

Inductive logic works by observing a large number of individual cases and then inferring the existence of a general theory or statement that governs all cases. So, if in observations of dogs a researcher found that, in all instances studied, the dogs had four legs it would be reasonable to infer that 'All dogs have four legs'. Conversely, a deductive approach would have started with a general model or statement and made predictions which must be true for all cases that fall within the relevant class. If 'All dogs have four legs' was true and 'Fido is a dog' is true then, logically, 'Fido must have four legs.'. The significant difference between inductive and deductive methods is that with induction no theory can exist without data (i.e. data must preceded theory) whereas deduction can make predictions about data that does not yet exist through logical steps (i.e. theory can, in specific circumstances, precede data).

A third logical model is called abduction. In abduction a set of observations can be used to infer a general rule which explains the phenomena observed. This general rule can then be used deductively to make a prediction which can, in turn, be tested. If the new data supports the hypothesis it is strengthened, if the data does not support the hypothesis it must be reviewed. Abduction is not as strong as formal deductive logic which, as in the example above, claims that Fido must have four legs because Fido is a dog. An abduction, based on the researcher's observations of dogs (codified in the four leg theory) and the knowledge that Fido is a dog it would be surprising if Fido did not have four legs. Abduction has combined existing knowledge (derived from observations of dogs) with new data (Fido looks like a dog) with a theory (all dogs have four legs) to create new knowledge and understanding. Scientific discoveries always require the integration of previous knowledge and new experience .

In order to draw out meaning from data, inductive approaches to data analysis typically search for similarities or differences (Klauer and Phye, 2008) in the attributes of objects or similarities or differences between the relationships between groups of objects. Figure 3.4, from their 2008 paper, illustrates how these basic processes can lead to classifications (sorting objects into groups), discriminations (identifying an object as not belonging to a group), recognising

relationships or distinguishing between relationships. Cross classification allows objects to be placed in different groups in different circumstances or according to different criteria while system construction allows the creation of a potentially predictive model to describe how the system of objects operates.

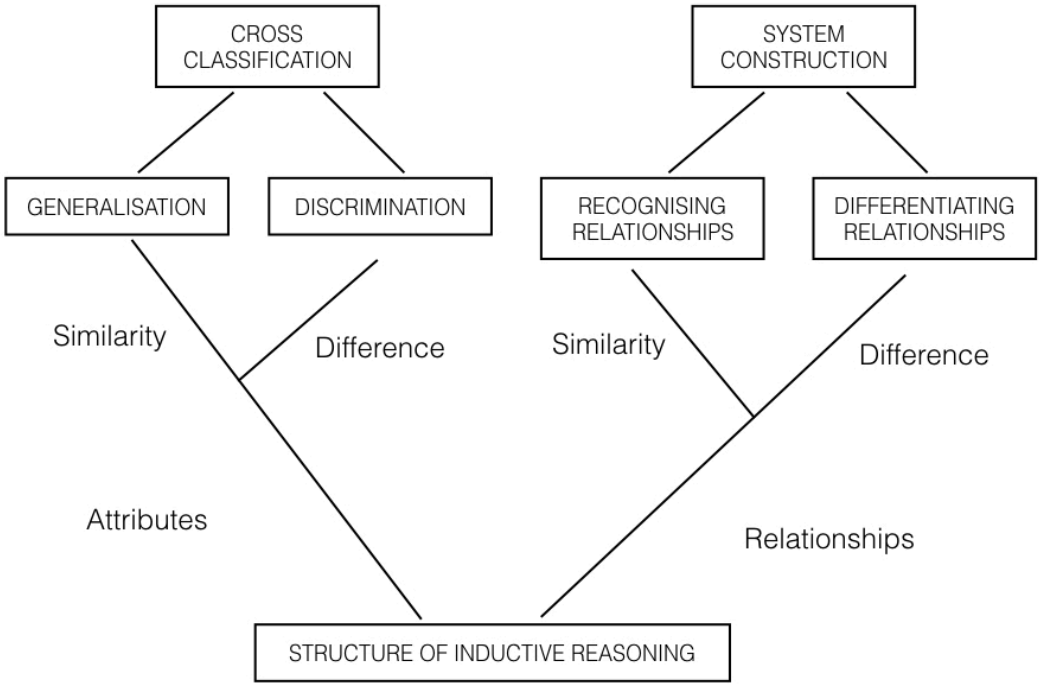

Figure 3.4: Strategy of inductive reasoning

3.4.6.1 From conversation to constructs

A PCT conversation is a collection of small conversations held sequentially and lasting, in total, up to an hour. Each small conversation focuses on a single group of elements (the number will depend on whether the conversation involves triadic or dyadic sorting techniques, see Section 3.4.3 Sorting techniques) and will produce at least one bipolar construct. The researcher will typically look into the data to find recurring themes or issues within each section. Conversations are typically recorded (audio-only or full video) to allow later transcription, detailed study and reflection.

The process involved in elicitation of the constructs typically involves a careful, line by line reading of the transcript noting points of interest throughout and recording these in the margin of the transcript. Once the researcher is familiar with the whole transcript, the individual sections can then be studied in more detail. At all times the researcher is using an inductive method looking to see what can be elicited from the data rather than an attempt to recognise pre-existing constructs in parts of the transcript.

Box 3.5 shows an example of how a transcribed conversation is coded. The extract is actually a sample from Teacher 2 conversation. The main text is in the large left hand column and has been marked with coloured overlay to link to notes in the narrow right hand column. The notes in the right hand column are not constructs. They are simply notes created by the researcher while studying the transcript. They will also draw on the tone of voice (in audio recordings), facial expressions and body language (when full video recording has also been used) as well as the typed transcript.

Box 3.5: Sample of transcribed conversation with codes marked

Transcript	Codes
GP OK, yeah, thats great. OK, from the point of view of creativity, how come you've chosen those? T2 Um, for me… um … sort of… if it's my favourite class then like the things that sort of really inspire me are creating these student centred projects for them to do and I feel my favourite classes … I'm able to do those things and its less structured and I can just really let them go away and use their own creativity to … I just put in a few sort of ideas and pathways for them to go down… and they can sort of explore it and they can go off and do it in their own way… and the less constraints I can put on them the greater it is and that's probably why its my favourite class because they can just go away and create and it's you know… that's why those two just stuck out to me… GP And the OFSTED inspection? T2 That, to me , just I don't do anything differently. That's why there's no creativity there for me. It's because there is no … there's no …. it's just so far from what I thinks got to do with creativity … I don't do anything differently so it's … so far removed and it's just … I don't feel like you should have to prepare for an OFSTED inspection either.	References to less structure and control over students References to teacher role as creator of starting points for students? References to creativity as fun - for teacher and students. Reference to lack of options in OFSTED lessons? Lack of options or 'differences' mean no creativity?

Looking at the triad of elements, the notes in the margin (further enlightened by issues that may have appeared in other sections of the transcript) and the transcript itself (often supplemented by listening to the audio recording or watching the video if available) a construct can be elicited that is consistent with the content of that part of the conversation. The process is then repeated for the next section of the conversation and by the end of the analysis a set of constructs, complete with descriptive poles, should have been produced.

The construct elicited from the sample transcript in Box 1 was concerned with optionality - the idea that where there was room for teachers, or students, to change their ideas as the task progressed they could be creative. (See Section 6.8) Where the activity was heavily structured with no option for change the space for creativity was limited or absent. The elicited construct, as produced by this analysis, must be validated by some method. The options for this are covered in section 3.4.7 Validity which follows.

Note that not all of the comments in Box 1 relate directly to the construct being explored in that particular triad. In the small example given there are references to the enjoyment the teacher derived from this class (marked in green in the transcript sample in Box 1). These ideas were picked up again in the conversation and supported elicitation of other constructs.

3.4.6 Validity

3.4.6.1 Validity

Validity (McLeod, 2007) can be ensured by reference to internal and external factors. Internals factors relate to whether any effects are due to the manipulation of the independent variable. It is particularly relevant in controlled experiments, e.g. a change in assessment procedures are presumed to lead to a change in motivation to complete the work set when an equivalent change was not seen in a control group that retained the old assessment scheme. External validity depends on the study's ability to be generalised to other situations or populations. This requires samples that are representative of the population as a whole. This is more likely to occur when the sample size is relatively large or has been specifically chosen to be representative of the larger population. This type of validity is more common in quantitative research where statistical tests are available to assess the degree of overlap between a sample and the population it represents.

3.4.6.2 Face validity

Face validity depends on the instrument addressing the phenomenon under investigation. In an investigation of the attitudes to careers in science amongst different groups of young peoples a questionnaire could be constructed that gathered data about their feelings and attitudes. Provided the questions concerned attitudes about science and career choices and were understood as such by the students answering them, the survey would have face validity. If the questionnaire simply gathered data about their performance in science tests and claimed that this would give a measure of their career aspirations because, it was suggested, students who were good at science, as measured by the test results, would have more positive attitudes towards careers in science this would not have face validity. The phenomenon being measured by the test

(performance in science tests) was not the phenomenon the researcher claimed was under investigation (career aspirations).

3.4.6.3 Inter-rater validity

Eliciting constructs from a transcript requires an open, inductive approach to the data rather than simply applying a set of rules. The constructs elicited should be a rigorous and reliable representation of the conversant's constructs and not a reflection of the researcher's interests or bias. One way to help protect against researcher bias is to provide the data to an independent rater who can go through the same process to see if the constructs generated match with the ones elected by the original researcher. Where the codes and constructs match the data is said to have inter-rater validity as two raters independently produced the same insights.

3.4.6.4 Respondent validity

In any conversation the words spoken are filtered by the listener their understanding and potential biases and prejudices. Frequent checking with the original speaker (e.g. phrases like 'So are you saying…?') can help to reduce misunderstandings during the conversations. This approach can be used when collecting data by asking these questions and by seeking approval from the respondent at the end of the process. In this instance, presenting the constructs elicited to the teacher and seeking they approval that they were a reasonable and recognisable statement of their own understanding. Where they agree that the constructs are reasonable and recognisable the constructs are said to show respondent validity.

3.5 Reflection

The key requirement identified at the start of this chapter was that any methodology employed should focus on the teachers' voice to develop a rich understanding of their understanding of creativity. This emphasis on listening and exploring teachers' understanding of creativity in their lessons rather than developing a classroom intervention or trialling a teaching strategy means that Personal Construct Theory (Kelly, 1955) is the most appropriate methodology of the ones considered. Particularly useful is PCT's facility to explore the constructs lying beneath the science teachers' understanding of creativity rather than merely re-emphasising the standard ideas about creativity (novelty and value). These constructs not only influence how teachers recognise creativity in their lessons but also guide appropriate responses in situations construed as creative. This will provide a much richer insight into teachers' understanding of creativity than simply another, scienceteacher- specific definition of creativity to add to the existing catalogue.

The detailed procedures used in this study for collecting and analysing data are discussed in Chapter 4.

Chapter 4: Methods

4.1 Introduction

Chapter 3: Methodology provided the justification for the use of Personal Construct Theory in this study. Chapter 4: Methods describes the procedures used to collect relevant data and engage in initial analysis to produce the constructs. Following this, Chapter 5: Findings will review all of the constructs produced during this initial analysis while Chapter 6: Discussion will explore their significance and meaning in more detail. Splitting the gathering and exploration of the data over three chapters is not accidental and reflects the increasing abstraction involved in the process. The procedures of Chapter 4 generate a set of conversations which are objectives records of a series of events Chapter 5 uses these recordings to generate a set of abstractions, in this case personal constructs, which, while agreed and validated by the participants, are a step away from simply reporting the content of the conversations. In Chapter 6 the constructs from Chapter 5 are further analysed and new abstractions, the categories, are generated which, in turn, are used to stimulate thinking about a possible model for understanding creativity in the science classroom.

Figure 4.1 shows the four key components of the methods used for the current study. The initial work, using the Storyline Method, (Beijaard, van Driel and Verloop, 1999), was necessary to create elements that would be appropriate and relevant to the context and so be more likely to drive useful conversations. These elements, and the procedure for eliciting the constructs, were trialled in a pilot and any necessary changes made before the data collection component was initiated following the pilot. Data collection occurred over 13 months and produced over ten hours of recorded audio with each teacher being involved in two conversations. Constructs, produced by the author from an analysis of the first conversation, were presented at a second conversation with the relevant teacher and agreed. 46 constructs were produced in total across all teachers. The data analysis which followed looked at these constructs through three viewpoints seeking to formulate ideas about the content of the constructs, the domains in which they operated and the role they played in the teachers' understanding and experience.

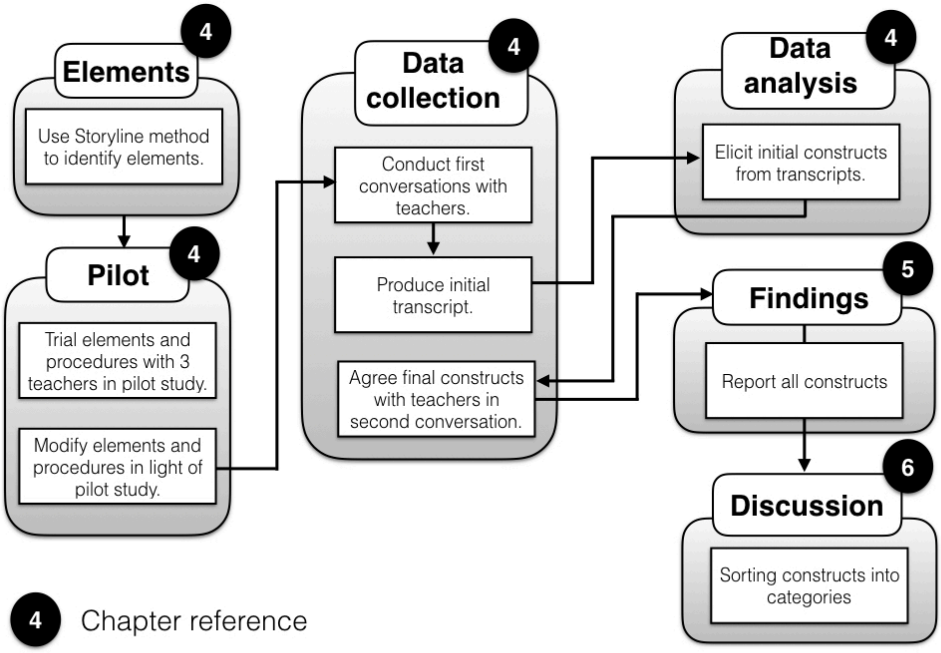

Figure 4.1: Overview of methods

4.2 Ethics statement

The study conformed to the published ethical policy of Sheffield Hallam University. This policy (https://www.shu.ac.uk/research/ethics-integrity-and-practice) requires all studies to meet relevant legal requirements (e.g. data protection, child protection) and operate within commonly agreed standards of good research practices as defined by Declaration of Helsinki, The Economic and Social Research Council (ESRC) Research Ethics Framework, by the Medical Research Council (MRC) and Research Councils UK (RCUK). These can be summarised as a commitment to:

- Beneficence - 'doing positive good'.
- Non-Malfeasance - 'doing no harm'.
- Integrity.
- Informed Consent.
- Confidentiality/Anonymity.
- Impartiality.

To ensure compliance with these standards an ethical assessment was carried out by Sheffield Hallam University Research Ethics Assessment Committee through a questionnaire submitted by the researcher.

In specific terms, all participants in this study were identified as non-vulnerable adults. They were invited to participate, made aware of the nature of the study and the methods that would be used and of their right to withdraw, for any reason, at any time during the process (see Appendix 1 for copies of the relevant invitation). Permission to make audio recordings of the research conversations was secured and copies of all documents relevant to the participants were made available to them (including full transcripts and analysis of the data) within two weeks of the conversation. All data is stored in a secure environment behind password-protection and none of the participants are identified in the study or in any documents produced by it.

The teachers gave their time freely to the study making themselves available for conversations during their busy school days. The study author visited the relevant teachers' schools, at times convenient to the teachers, to reduce the disruption to their work. The conversations were also conducted in a non-threatening manner and no report made to other members of the department on anything said during them. No teachers were paid for their contribution. However, a number did remark at how much they had enjoyed the process, both the thinking about creativity in their classrooms and the opportunity to talk with someone outside the school about deeply-held beliefs, and all expressed a willingness to be involved in further research.

4.3 Identifying elements

4.3.1 Productive elements

As described in Section 3.4.2: Elements, elements can be people, events or objects that are significant in the field of interest and meaningful to the participant(s). In this study, elements were

supplied to participants to enable comparisons between different participants' constructs. While it would have been possible to generate these elements solely from the researcher's perception of the existing literature, a wider range of inputs was considered more likely to produce elements which were significant to a wider range of people. Given the importance of these elements in driving productive conversations it was decided to gather data from a set of individuals, who were not going to be involved in the final project, to create a suitable list of elements. These elements would form the common set to be used in all conversations during the data collection phase and would be independent of the researchers and the participants of the conversations. This procedure is indicated in the first box in Figure 4.1 Project overview and occurs prior to the pilot study to refine the method.

The Storyline Method (Beijaard, van Driel and Verloop, 1999) was used to structure conversations which would help to identify this selection of elements to be used in the pilot which followed. This technique was chosen because the study author had previously found it a useful way to structure conversations while offering considerable freedom to participants to drive the discussion.

4.3.2 Storyline sample

11 people were interviewed between September and December 2009. These people were selected because they had relevant experience of education or worked in industries defined as 'creative industries' by the UK Department of Culture, Media and Sport, (DCMS 2011,2014). All were known to the author of this study. They included two teachers who had experience in the proposed age range (UK secondary school, ages 11-16), four educationalists and trainers working in science education, a fashion designer, a graphic artist and a software producer. The group contained seven males and four females across a range of ages from 26 to 62.

Table 4.2: Demographic data for storyline sample

Person	Sex	Age	Profession
1	M	21-30	Graphic artist.
2	F	31-40	Head of Science, secondary school.
3	F	31-40	University researcher.
4	M	31-40	Fashion designer and musician.
5	M	41-50	Curriculum developer, formerly a science teacher in a secondary school.
6	F	41-50	University administrative assistant, proprietor of cake-decorating business.
7	M	51-60	Software developer, formerly a science teacher in a secondary school.
8	M	51-60	Curriculum developer, formerly a science teacher in a secondary school.
9	M	51-60	Management consultant, freelance scriptwriter.
10	F	51-60	Curriculum developer, formerly a science teacher in a secondary school.

Person	Sex	Age	Profession
11	M	61-70	Management consultant specialising in team working and innovation.

4.3.3 Storyline procedure

In storyline method (Beijaard, Van Driel and Verloop, 1999), participants are given a pair of axes with their perceived level of a factor (in this case, their creativity at work) up the y-axis and time along the x-axis. The present day is fixed at the far right of the x-axis.The exemplar trace in Figure 4.3 shows many of the typical aspects of a completed storyline plot. The numbers up the y-axis are present to give the participants an idea of the scale and are not used in the final analysis. It has been modified slightly from Beijaard *et al*'s original in that it includes a section for the future. This offered opportunities for interviewees to speculate and often revealed further insights.

The interviewer introduced the blank storyline form to the interviewee and explained that it is an attempt to record their creative output at various stages during their working life. The interviewer then asked the interviewee to score their present level of creative output from zero (no significant creative output) to seven (high level of creative output) and mark it on the line labelled 'Today' on the form. Then they were asked to draw a line backwards through time (towards the left) showing rises or falls in their creative output across their life. Each interview was conducted individually.

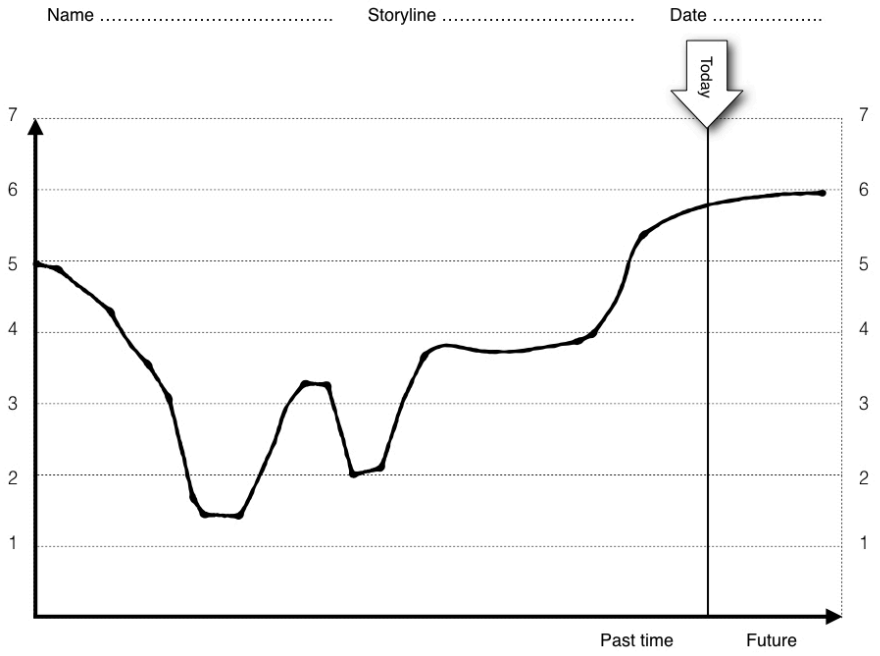

Figure 4.3: An exemplar completed storyline form

Since the people chosen were of different ages the x-axis did not have values marked although they were all asked to track backwards to the start of their secondary schooling at the value x=0. Sometimes this involved resetting the initial score to make room for higher or lower levels as the line rose and fell. The x-axis labels are typically only rough labels to identify times during the interviewee's life that they felt had a significant effect on their creative output - either positively or negatively. The scales consequently may not be consistent or strictly linear. Similarly, in these conversations, the y-axis only show people's perception of their creativity and comparing the total height of the graph between two people is meaningless. Two different people may have very different ideas of what merits a 'seven' or a 'three' in the creativity scale. Given these caveats, the trace identifies critical events (rises or falls in creativity) and gives an idea of the scale and speed of these events.

Once the line had been drawn the conversation explored the reasons for rises or falls in creativity. For example, 'Why did the line rise so steeply here?' 'How did your life or work change to make this happen?' This allowed the interviewees to describe the reasons for any changes and, with supportive questions from the interviewer as appropriate, explore their understanding of creativity. This focus on their own story puts the interviewee in a relatively powerful position in the conversation and, from experience, they are both motivated and skilled in their analysis. Often they are surprised as they reflect, usually for the first time and at some distance, on their own creative activity. Most interviewees claimed that they enjoyed the process and found it enlightening. All interviews were recorded and transcribed for later analysis. This analysis involved identifying themes that ran across multiple conversations, e.g. the impact of new management, the effect of time pressures on creative output, and these were used to inform the creation of elements which could be useful in the coming PCT conversations. The following section describes the findings from the conversations and how they were used to inform the creation of the elements used in the main pilot.

4.3.4 Findings from the conversations

All of the interviews showed that creative output at work is not a fixed quantity with traces rising and falling in every diagram. The participants also used almost the full range of the y-axis implying that these changes were not minor or inconsequential.

Changes in jobs often produced a fall in creative output and people typically explained that they were learning new skills or settling into a new environment and so felt constrained by performance issues. As their experience in the new role grew their creativity began to rise again. Falls in creativity were also ascribed in a number of interviews to new management structures and a sense of increased interference or micromanagement of their work by superiors. Two interviewees mentioned a 'new head of department' who did not encourage creativity and one teacher talked about the introduction of new assessment procedures for public examinations which they felt constrained experimentation and creativity.

Some job changes produced a rise and these were explained in terms of greater freedom or a sense of personal validation produced by promotion. No-one mentioned the arrival of a new head

of department or supervisor as a cause of increased creative output. However, involvement in external projects (i.e. beyond their normal job role) was cited as contributing to a rise in creative output. Two examples were a curriculum development project (Pupils Researcher Initiative, 1996 - 2000) where one interviewee felt both pressure and license to 'do something new'. One interviewee described becoming involved in writing a GCSE specification which involved working with a new group of people who were 'very creative' and this encouraged the interviewee's own creativity. Another talked of joining a writing team for a GCSE science textbook and noticing the same effect.

After completing the discussion about creative output in their professional life the interviewees were asked to sketch in another line using the same set of axes. This trace was to reflect their creative output in their personal lives, i.e. everything other than work. Typically this line was a mirror image of their professional work line. Where the professional line dropped the personal line rose and where the professional output rose so the personal line fell. One interviewee spoke of feeling frustrated at work due to a change to a more controlling style of management with a consequent fall in his creative output which matched a rise in the efforts he put into playing with friends in a band and stimulated him to start writing his own songs for the first time - previously they had only played covers. Another told of how his job changed and became much easier and more mundane so he began work on a film script about the life of Mary Secole, a black nurse who cared for British soldiers in the Crimean War. This seemed to imply that creative output was not simply a result of creativity-friendly management or collaborative co-workers because when these circumstances were absent and creative output was blocked in one area it would reappear in other facets of the person's life. For the people interviewed creative activity seemed less an option to be taken up in favourable circumstances but an inevitable output of their personality.

4.3.5 Identifying elements

Table 4.4 lists the elements generated from the initial storyline work and reading of the existing literature concerning creativity in classrooms. A number of the Storyline conversations made reference to external pressures or management interference in their work. To try to capture this experience the elements 'Public assessments and examinations' and 'My biggest problem in teaching science' were included. The reference to 'biggest problem' was because the teachers in the Storyline sample all identified the bureaucracy and official directives as their biggest problems. Both seemed to link to the notion of external control and monitoring.

Similarly, the element 'What I do to relax in my own time' was added as almost all of the storyline participants readily volunteered information about their novels, songs, film scripts and artwork.

Table 4.4: Elements for pilot study

Element	Justification for inclusion of element
My decision to become a science teacher.	These elements concern their own education and their decision to become a science teacher. It also introduced

Element	Justification for inclusion of element
My most creative science teacher.	opportunities to speak of the 'ideal science teacher' when considering their most creative teacher.
Public examination and assessments.	These were mentioned by all of the teachers in the interviews and represent a school-based equivalent for the 'external pressures' mentioned by other interviewees.
My favourite class.	These elements reflect day-to-day experiences or issues for teachers - both the positive and the negative aspects of the work. They reflect the comments from the storyline interviews of creativity at work.
My biggest problem in teaching science.	
My most creative science lesson.	
What I do to relax in my spare time.	These elements were included to allow access to creativity outside the teachers' professional lives.
My least creative activity.	
Me as a creative person.	

4.4 The pilot study

A pilot study was used to check the appropriateness of the elements suggested in Table 2, to test and modify the procedure (a triadic sorting approach was selected) and to rehearse the skills needed to operate it effectively.

4.4.1 The pilot sample

Three qualified science teachers practising in the same age ranges (11-16) as the proposed live study were selected for the pilot study. Outline demographic data is given in Table 4.5.

Table 4.5: Demographic data about teachers in the pilot study.

Characteristic	Teacher 1	Teacher 2	Teacher 3
Age	26	57	38
Teaching experience	3.5 years	36 years	10.5 years
Role	Science teacher	Deputy Headteacher	Head of Science
Main subject area	Science	Chemistry	Physics
School type and age range of students	An independent Roman Catholic school (3-13)	A city centre comprehensive school in a predominantly white area. (11-19)	A Community College on the outskirts of the city with an ethnically mixed population. (14-18)

4.4.2 The pilot procedure

To simplify the mechanics of the sorting procedure, nine cards were created with a single element from column 1 in Table 2: Elements for pilot study printed on each in large type. The cards were

numbered to aid note-taking during the conversation but it was pointed out that the numbers were simply there as an administrative convenience and had no other significance.

The sorting procedure was triadic for reasons described in Chapter 3.4.3: Sorting techniques. In triadic sorting two elements from the pool are selected because they are similar in some way with a single element subsequently identified as being different. The reason for creating the triad (two similar - one different) are then explored by discussion. In this implementation of the method, all nine cards were laid out on the table face up and the participants were asked to identify two which were similar (these became the emergent pole of the construct) in some way and one which was different (this became the contrast pole of the construct). This corresponds to Step 1 in Figure 4.6. Once the triad had been selected a conversation was used to uncover the reasons for the choices made. The conversation was informal with the researcher asking open questions (e.g. from Teacher 3 conversation ‘Can you explain to me why you you've made that choice? You've made it very quickly…’ and ‘And it’s very creative because …?’) , to promote exploration and elaboration of the reasons for the triad choices from the teacher. After the participant felt that they had nothing more to say about the particular triad the cards were returned to the table and a new triad produced and the process repeated. Any of the cards could be re-used or a completely new triad could be created. Typically, a conversation lasted 35-40 minutes and produced 5-6 triads. The conversation was audio recorded and transcribed for later analysis.

Using the transcript, and the audio recording when necessary, the researcher identified the construct apparently used by the teacher to produce the triad and created emergent and contrast poles for this construct. This corresponds to Step 2 in the diagram. The reason for doing this after the conversation had ended was to allow more time for reflection and thought compared with identifying the construct in the initial conversation with the participant. Step 3 is the final stage of the procedure. Here the constructs were reported back to the participant at a separate meeting (usually 2 weeks later) and any necessary changes made until the teacher was satisfied that the constructs and the poles reflected their thinking accurately.

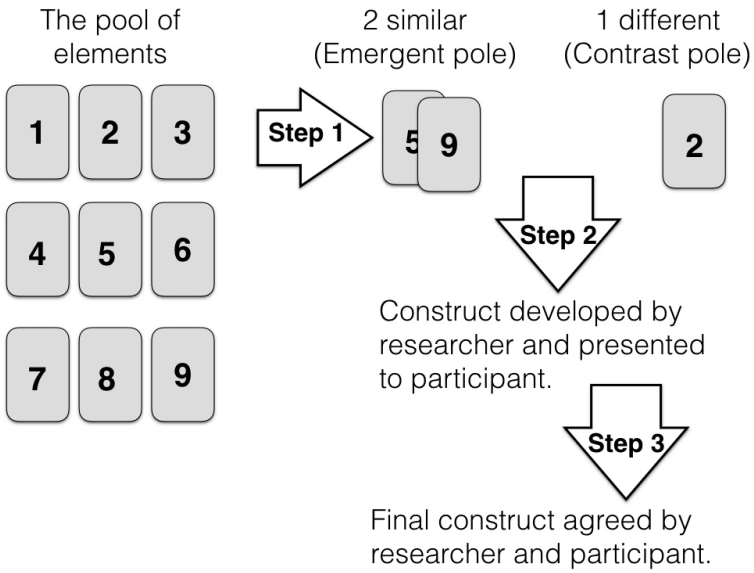

Figure 4.6: Triadic sorting procedure

4.4.3 Pilot findings and analysis

All of the teachers involved in the pilot study were invited to reflect on the process and make any suggestions for ways the researcher could optimise the experience for the teacher. The researcher independently also analysed each pilot conversation to gain any insights for improvements to the initial elements or technique. The sections which follow describe some of these conversations.

Where quotes are provided from the transcript these are coded as '<Teacher>/p <page number in transcript>/<line number where extract starts>' so 'Pilot Teacher 1/p3/17' means the quote is from the conversation with Pilot Teacher 1 and can be found on page three of the transcript starting at line 17.

4.4.3.1 Teacher 1

The conversation with Teacher 1 was somewhat unfocussed and drifted often into discussions of good teaching and learning rather than being specifically about creativity in the science classroom. A lot of the comments focussed on teacher performance rather than their understanding of creativity.

> ' …a bit more confidence in your own teaching ability um you're able to give them a wider perspective in that if you present concepts through modelling, metaphors, analogies all that sort of thing …' (Pilot Teacher 1, p4/9)
>
> 'Because you are trying to find ways to make what can be sterile, dry boring concepts within curriculum interesting, relevant and exciting.' (Pilot Teacher 1, p7/28)

Despite reminders to return to the topic of creativity the participant spent a lot of the conversation listing the names of teaching techniques and approaches without describing how he thought these were linked to creativity.

However, it was possible to develop some constructs from the triads created and these were presented to the teacher, modified slightly and subsequently agreed. Table 4.7 lists the final constructs agreed with Teacher 1.

Table 4.7: Teacher 1 constructs

Emergent	Contrast
Practical, hands-on experimental work.	Theoretical, paper-based work.
Non-obvious links to syllabus demands.	Clear link to syllabus demands.
Student-centred, more independent learning activities	Highly directed, structured learning activities.
Opportunities to link ideas. Application and synthesis.	Simpler, repetitive tasks directed at lower skill levels and memory.
Different, 'off piste' teaching and presentation approaches	Predictable, formulaic approaches and tasks.
Boring, sterile, dry content.	Interesting, relevant and exciting content.

As a result of the conversation with Pilot Teacher 1 the researcher decided to try to provide a clearer focus on creativity by reminding teachers during the discussion about the purpose of the conversations (exploring their understanding of creativity) and by gently shutting down digressions into 'good teaching'.

4.4.3.2 Teacher 2

The conversation with Teacher 2 started very slowly with long pauses between contributions. At first the teacher found it very difficult to relate creativity to the elements on the cards and the first suggested triad was not related to creativity at all but to the nature of the specific elements as this extract from the transcript demonstrates:

> T2 Um… I s'pose these two < pointing at cards 7: My least creative activity and 8: My most creative science lesson.>… because they are activity based …
>
> GP Right
>
> T2 They're events
>
> GP So they go together?
>
> T2 And that's < pointing at card 2: My favourite class> sort of those on the receiving end. (Pilot Teacher 2/p1/10)
>
> (T2 = Pilot Teacher 2; GP = researcher; <text in brackets describes actions of T2.>)

The conversation continued but the elements became a problem as Pilot Teacher 2 did not seem to be able to make the connection between them and creativity easily. After a while the cards were dispensed with, a mutually agreed decision, and the discussion continued. It became more fruitful, if less structured, from there on and constructs could be extracted from the conversation. Table 4.8 summarises the constructs agreed with Teacher 2.

Table 4.8: Teacher 2 constructs

Emergent	Contrast
Drawing together ideas and synthesising them for a purpose.	Learning /memorising disconnected facts.
Thinking in depth about a topic.	Being busy (practically or on paper) but with limited purpose.
Working through a process, making decisions at key points.	Doing disconnected or individual activities with no reflection.
Involvement, 'being gripped' and with room to follow something in your own direction.	Doing practical work with no purpose or interest beyond being less boring than writing.

As a result of the unfocused conversations with Pilot Teacher 1 and 2 a formal script was prepared to read out to Pilot Teacher 3 prior to the conversation. This identified the purpose and procedures of the project more explicitly. It was also decided to adopt a more directed style of questioning with the researcher asking the teacher to expand on topics of relevance with relation to creativity rather than allowing them completely free rein in driving the conversation. The script is reproduced in Box 4.9.

Box 4.9: Script used to introduce all conversations

I am researching teachers' perceptions of the place of creativity in their science classrooms for my PhD.

I would like to have a two conversations with you about your personal perception of creativity in your science classroom.

Here are nine cards that relate in some way to creativity in your science classroom . They have come from my personal thinking and experience, conversations with teachers and from a review of some of the issues identified by researchers in the field.The numbers on the cards are purely for identification and have no other meaning.

Please could you look at the nine and, firstly, assure yourself that each one is clear to you. Do you want any clarification about any of them?

Secondly, and remembering that we are here to talk about your understanding of creativity in the science classroom, please pick two cards that you feel go together in some way. Then pick a third which you feel is different to your existing pair. We will then discuss the reasons you have for making your choices.

When we have explored the thinking behind that triad I will then ask you to pick another triad. You can use some of your existing choices or three different ones. We will then discuss that triad and so on.

The conversation, which will last no more than 40 minutes, will be recorded and I will provide you with a copy of the script for you to check. I will try to draw out some of the key issues you seem to be using to create your triads and discuss these with you. You will obviously be able to clarify my thinking if I have misunderstood you in any way. These triads, and my analysis should reflect your thinking - not mine.

We will then have another conversation to explore the impact of these on creativity in your classroom.

4.4.3.3 Teacher 3

This conversation was more focussed, slightly more formal than the previous pilot conversations and was preceded by a script explaining the purpose of the conversation (see Box 4.9). The interviewer took more chances to remind the interviewee that the conversation was about their

understanding of creativity in the science classroom and this produced a more useful conversation which made it easier to locate constructs. Table 4.10 summarises the constructs agreed with Teacher 3.

Table 4.10: Teacher 3 constructs

Emergent	Implicit
Under my control.	Controlled by others.
Requires personal decisions.	Formulaic, algorithmic.
Produces surprises in terms of procedure and outputs.	Predictable outputs, often known in advance.
Produces an attractive product.	Product is drab or uninteresting.
Requires time and effort.	Can be easy, unchallenging.
Exciting, entertaining, engaging.	Boring.
Rare or special in some way.	Common, mundane.

Teacher 3 also engaged in a second interview where the constructs identified by the researcher were discussed. The teacher agreed that they were fair representations.

4.4.4 Optimising the elements

The elements are a key feature of PCT conversations (Walker, 2007) Where they are not used, or, even worse, misunderstood, the constructs elicited during the conversations could be irrelevant, poorly defined or absent (if the elements did not provide opportunities to use those constructs). The pilot provided an opportunity to test the elements against these three criteria: use, efficiency and clarity. If any elements were not used over the three pilot conversations it was assumed that they were not seen as relevant to the topic by the participants. If the dialogue generated by the elements was only poorly connected to creativity or spiralled off into discussions of creativity outside the classroom the elements were seen to have low efficiency - they failed to generate conversations that allowed the elicitation of rich, well-defined constructs. If there were questions about the meaning of an element it was assumed that the expression was difficult to understand, even if the element was then used in the subsequent conversation. Equally, the pilot conversations also led to development of completely novel elements. Table 4.11 shows the pilot elements ranked by their use in pilot conversations.

Table 4.11: Pilot elements

Frequency of use	Element
4	Public examination and assessments.
4	My most creative science teacher.
4	My decision to become a science teacher.

Frequency of use	Element
4	My least creative activity.
4	My most creative science lesson.
3	My favourite class.
3	What I do to relax in my spare time.
2	Me as a creative person.
1	My biggest problem in teaching science.

Following the pilot, elements which were rarely used to create triads ('My biggest problem in teaching science' and 'Me as a creative person') were deleted. The two places this made vacant in the set of nine elements were taken by two new elements that picked up topics of interest from the pilot ('Attending a Science Department meeting after school' and 'Preparing for an OFSTED inspection'). Both of these new elements relate to manifestations of external pressure acting on the teachers, an issue which appeared repeatedly during the pilot conversations. In summary, these new elements were not modifications of the originals but replacements for them.

Some elements ('My decision to become a science teacher.' and 'What I do to relax in my spare time.') were used relatively frequently but generated conversation that was rather general and not focussed on the central issue of creativity in a science classroom. These elements were removed and replaced with elements with a clearer classroom focus. Again, the new elements were replacements rather than modifications to focus the main study's conversations more closely around the teachers' understanding of creativity in their classrooms.

During the conversations, some of the elements generated questions about their meaning and so failed the clarity test. One example was the element 'My most creative science teacher' which led to two of the three teachers in the pilot asking if it referred to a colleague (present or in the past) or a teacher who had taught them when they were at school. To simplify and focus all of the elements they were recast to be phrases or sentences describing some of the typical duties of a teacher. This reduced confusion because the new elements were clearly related to the teachers' experiences rather than to more abstract concepts. This reflected the conversation generated during the pilot where the teachers typically connected elements with particular examples from their own experiences. These are modifications of language rather than replacements of the elements. All elements were modified to this new form (describing typical teacher actions) to ensure consistency and in the subsequent data collection stage of the study only one teacher asked one question about the meaning of a single element which implied that this strategy was successful. Table 4.12 provides a list of the elements used in the main study.

Table 4.12: Elements used in main study

Element used in main study
Teaching a revision lesson for an upcoming assessment.
Planning a lesson for my favourite class.
Attending a Science Department meeting after school.
Researching a topic I do not know about but will be expected to teach.
Facilitating student-centred science projects.
Marking an assessment for GCSE or other public examination.
Covering a supply lesson using a lesson plan supplied by the absent teacher.
Providing feedback for students about their work.
Preparing for an OFSTED inspection.

4.4.5 Optimising the procedure

The pilot conversations were very open with the teacher leading them and the researcher taking notes and asking open questions. This meant that the teachers had plenty of opportunity to explore their ideas in conversation with the researcher and supported the notion that they were not being forced into particular positions by intrusive questioning from the researcher. However, the open nature of the conversation had allowed some drifting into general talk of 'good teaching', specific teaching techniques (e.g. a long discussion about making cupcakes in a mug with Pilot Teacher 1) or other diversions which did not allow elicitation of the constructs.

To tackle this issue, a script (See Box 1: Script used to introduce all conversations above) was prepared to read out at the start of the conversation. Teachers were also asked specifically if they had any questions about the elements on the cards to clear up any ambiguity. The researcher also took more opportunities to focus the conversations on the issue of creativity using questions such as 'And how does this relate to your understanding of creativity…?' and instructions like 'Remember, we are talking about creativity … tell me the story of this triad…'. This seemed to provide sufficient guidance while still allowing the teachers the opportunity to tell their own story.

4.5 Data collection

4.5.1 The main study data collection activity

The conversations that formed the main data collection activity took place between Jan 2015 and Feb 2016. All were audio recorded, transcribed and analysed for constructs. The transcripts were supplied to the teachers within a fortnight of the recording and any constructs identified were clarified and agreed with the teachers in a second conversation.

4.5.2 Main study sample

Table 4.13 shows the demographics for the seven teachers involved in the data collection activity. These teachers were known to the researcher through their involvement with other SHU projects and were described by SHU colleagues as being teachers who were interested in creativity. However, there was no formal entrance qualification for the study beyond an interest in the topic and a willingness to become involved. A number of the younger teachers were recommended by their Heads of Department (often the primary contact for SHU when dealing with Science Departments over curriculum projects or research initiatives).

Table 4.13: Demographic data for teachers involved in main conversations

Characteristic	T1	T2	T3	T4	T5	T6	T7
Sex	F	M	M	M	M	F	M
Age range	31-40	31-40	31-40	26-30	41-50	31-40	31-40
Teaching experience / years	8	4	12	5	20	18	7
Role	Science teacher	Deputy Head of Science	Head of Science	Science Teacher	Science Teacher	Science Teacher	Deputy Head of Science
Main subject area	Science	Chemistry	Biology and Chemistry	Physics	Biology	Chemistry	Biology
School nature and age range of students	Community College (11-16)		Roman Catholic Comprehensive School (11-16)		Independent grammar school (11-19)		State comprehensive school (11-16)

4.5.3 Data collection procedure

The procedure used for all conversations followed the approach optimised during the pilot. This used a script (See Box 1 in section 4.3.3 for the full script) to introduce the conversation and then 35-40 minutes of discussion which was recorded (audio) and transcribed. At the end of every conversation the cards were placed to one side and respondents asked if they had any further thoughts or wanted to say anything that had not yet been covered. This opportunity for free conversation allowed respondents to share more freely, without the constraints of the elements and constructs, about aspects of creativity that they felt were important but had been missed. All conversations were with individual teachers.

4.5.4 From conversations to constructs

An initial analysis of the transcript, supported by the audio file where necessary to clarify nuances, was completed to produce a set of constructs with descriptive poles. These are called the presumptive constructs as they were elicited by the researcher and had not been validated by the

teacher. For reasons given in Section 3.4.5 this analysis proceeded inductively and produced a set of constructs for each conversation for each teacher.

Following the initial elicitation of constructs, the transcript was put aside for a few days and then the process repeated to see if it produced the same analysis. The final set of proposed constructs was thus a compromise of two attempts at analysis although in almost all cases there was very little change between the two versions.

Once the presumptive constructs were available they were supplied to the teacher in an email alongside a copy of the transcript. A face-to-face meeting was then organised to discuss the constructs produced and agree any modifications to ensure that the final, agreed constructs were an accurate picture of the teacher's position. Chapter 5: Findings which follows describes all of the constructs in detail.

4.5.5 Validity

4.5.5.1 Face validity

Face validity depends on the instrument addressing the phenomenon under investigation. In this instance, the instrument is the conversation, generated by the elements, and the PCT analysis. The elements were derived from a review of the existing literature about creativity in science classrooms and a storyline technique (Beijaard, van Driel, Verloop, 1999) exercise with educators and creative workers. They were then tested in a pilot with practising teachers and a number of the original suggestions were changed in the light of that process to ensure they were more tightly embedded in teachers' day-to-day experiences. If the elements were invalid they would not have been used during the conversations but all were used to generate useful conversations. Also, all teachers were asked if they understood the elements as presented on the cards and only one or two cards in the whole live study required further explanation by the researcher. Again, this implies that the elements were understandable, relevant and useful. The method used in the final study was thus fully trialled, carried out but a single researcher and common across all teachers.

4.5.5.2 Inter-rater validity

All of the transcripts were made available to a reviewer who coded them independently and without any prior sight of the codes used in the first analysis. These were then checked against the codes and constructs provided by the researcher and were seen to match with no significant differences. This provided inter-rater validity.

4.5.5.3 Respondent validity

The constructs were also shared with the relevant teachers and were changed as necessary to ensure the teacher was happy that the wording captured their understanding correctly. Only one of the constructs from all of 46 produced was changed by the teacher. This change was a minor modification involving a slight shift in emphasis from 'rarity' to 'novelty'.

4.6 Reflection

Working with participants to elicit personal constructs is a demanding task that involves a combination of gentle guidance and open acceptance. I did not always find the balance between these two requirements easy to achieve and the pilot provided an extremely valuable way to hone my skills, and the detailed procedure, prior to collecting data to be used in the final study. The changes to the elements used also helped to focus the activity more effectively on creativity in science classrooms as opposed to creativity more generally. It was gratifying to find that all participants agreed, during their second conversations, that the constructs elicited (listed and explored in detail in Chapter 5) did represent their thinking well and this gave me more confidence to explore them in more detail. The constructs certainly appeared valid and a useful description of the participants' understanding, a key requirement for the chosen methodology (see Chapter 3).

The 46 constructs produced as a result of the data-collection exercise are described in Chapter 5: Findings and their implications are explored in Chapter 6: Discussion.

Chapter 5: Findings

5.1 Introduction

Chapter 5 catalogues and describes the constructs employed by each teacher. Each construct will be discussed to clarify any subtle nuances in meaning and to show how it was elicited from the transcript. All 46 constructs are listed at the end of the chapter. These 46 constructs are used in the further analysis into categories and roles that follows in Chapter 6: Discussion.

The division of the account of any project that uses inductive logic into simple chapters can be problematic since it could be seen to imply that the findings are independent of the analysis and that the discussion follows after the analysis and has no impact on that analysis. The inductive reasoning used in this study is iterative and cyclical in almost every stage and uses constant comparison (Thornberg, 2012), familiar to users of grounded theory methodologies, throughout to inform both analysis of data in Chapter 5 and discussion in Chapter 6.

While these features are probably not unique to this study they do mean that the chapters devoted to findings, analysis and discussion interweave with raw data from the conversation transcripts appearing in all of them. This is intentional and is included to demonstrate the close link between this data and the ideas being suggested.

5.2 Teacher constructs

5.2.1 Use of elements

PCT conversations make use of elements to allow the elicitation of constructs. The elements used in this study are listed in Table 5.1. Further discussion concerning the selection of these particular elements is provided in the discussion of the pilot study in Section 4.4 of Chapter 4: Methods.

Table 5.1: Elements

Element No:	Element text
1	Teaching a revision lesson for an upcoming assessment.
2	Planning a lesson for my favourite class.
3	Attending a Science Department meeting after school.
4	Researching a topic I do not know about but will be expected to teach.
5	Facilitating student-centred science projects.
6	Marking an assessment for GCSE or other public examination.
7	Covering a supply lesson using a lesson plan supplied by the absent teacher.
8	Providing feedback for students about their work.
9	Preparing for an OFSTED inspection.

Analysis of the PCT conversations from the seven teachers in this study produced a total of 46 constructs. Table 5.2 shows summary data about the elements used and constructs elicited from each teacher. So, eight constructs were elicited from the conversation with Teacher 1. Teacher 1 used element 1 <Teaching a revision lesson for an upcoming assessment.> three times during the conversation, element 2 <Planning a lesson for my favourite class.> three times but element 3 <Attending a Science Department meeting after school.> only twice and so on.

Table 5.2: Elements used in each teacher conversation

Teacher	Constructs produced	Elements used to generate constructs								
		1	2	3	4	5	6	7	8	9
1	8	3	3	2	2	5	1	1	2	5
2	6	4	2	3	1	3	1	2	1	1
3	7	3	2	1	3	3	3	2	3	1
4	7	4	4	1	1	2	4	1	2	2
5	7	3	2	3	2	3	1	2	3	3
6	5	2	1	1	2	2	2	2	2	0
7	6	3	3	2	1	3	1	1	2	1
Totals	46	22	17	13	12	21	13	11	15	13

All elements were used at least once by every teacher in the main study except for 9<Preparing for an OFSTED inspection> which was not used by Teacher 6. Teacher 6 taught in an independent school which had never been inspected by OFSTED so he had no direct experience of this element.

5.2.2 Reporting format for teacher constructs

The discussion of the constructs is supported by reference to the transcripts of the conversations. These references are coded (p*x*/*y*) where *x* is the page number of the transcript and *y* the line on the page. This quote from the conversation with Teacher 1 shows that the text starts on page 1 of the transcript at line 34.

> ‘not creative at all to me … you have to mark to a mark scheme… it’s black and white, there’s no grey areas.’ (p1/34)

All quotes are verbatim from the audio recording with some tidying to avoid verbal tics. Where text appears in <sharp brackets> this has been added by the researcher for clarity. It may refer to the wording of the element on the card or a clear reference to a phrase not quoted directly in the

extract. For example in the quote from Teacher 2 below the OFSTED reference clarifies the word ‘here’ (the teacher was pointing to the element card) and <try new things> picks up the topic of the exchange from a few lines earlier in the transcript.:

> ‘… whereas here < in the OFSTED lesson>you can’t <try new things>, you have to stick with what you're doing and what you know best.’ (p3/29)

Each Triad description that follows has the same reporting structure. The first table shows the elements selected in columns labelled ‘Pair’ (containing the two elements selected as similar) and ‘Different’ (the single element selected as different from the pair). The text that follows picks up the main themes of the ensuing discussion with quotes from the transcripts to support the analysis. Finally each Triad description contains a table of constructs which identifies the Emergent pole (based on the similarity of the pair) and the Contrast pole (based on the difference of the single element from the pair). A single triad may produce more than one construct.

At the end of each conversation the cards were dispensed with and teachers were asked if they had anything else to add or to emphasise. These comments did not produce new constructs but added clarification about the teacher’s overall feelings and thoughts. These comments are included at the end of each conversation under the heading ‘Free conversation’.

5.3.1 Teacher 1

5.3.1.1 First triad

Pair	Different
2: Planning a lesson for my favourite class. 7: Providing feedback for students about their work.	6: Marking an assessment for GCSE or other public examination.

The first triad focussed on the presence or absence of options where generating options was a key component of creativity. The marking element, with its detailed and prescriptive procedures to ensure reliability of the eventual score, was dismissed as not creative.

> ‘Well, marking and assessment for GCSE… that’s … not creative at all to me … you have to mark to a mark scheme… it’s black and white, there’s no grey areas.’ (p1/34)

This contrasted with planning a lesson or providing feedback about their learning.

> ‘Whereas, when you're planning a lesson or providing feedback about students’ work there are so many different ways you can do that.’ (p2/1)

There was no suggestion at this point that one was ‘better’ than the other - they were just different teaching activities.

> ‘One is to help the students to learn and the other is assessing their learning.’ (p2/7)

It was recognised that one, the marking, had heavily controlled procedures whereas the other, planning and providing feedback, could be achieved in number of different ways which were to some extent under the teacher’s control.

Emergent pole	Contrast pole
Creativity depends on, and generates, options and having a range of possible ways forward.	No freedom to deviate from provided plans makes creativity impossible and unnecessary or irrelevant.

5.3.1.2 Second triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 4: Researching a topic I do not know about but will be expected to teach.	9: Preparing for an OFSTED inspection.

The second triad explored risk and how it could be embraced and managed. An inspection by OFSTED (the government body charged with inspecting educational institutions in the UK) is a significant event for teachers given that a poor OFSTED report can lead to a fall in recruitment of students and even school closure. Consequently, if an OFSTED inspector was observing a lesson few risks were wise.

> 'You can't take as many risks with how you plan for an OFSTED inspection. You have to make sure you're doing certain things … that you're told to …' (p3/5)

> '… whereas here < in the OFSTED lesson>you can't <try new things>, you have to stick with what you're doing and what you know best.' (p3/29)

This 'stay safe' approach was contrasted to creativity which was seen as requiring the taking of risks.

> 'You have to take a risk to be creative in my opinion.' (p3/16)

Examples of these risks were given, indicating that they were not just a non-specific lack of courage, or feeling nervous about trying some thing new, but real concerns about identifiable issues relating to student behaviour and learning.

> 'How are they going to take that? Are they going to learn from it or not? Or are they going to behave well in the classroom doing that or are they going to be able to learn from each other if you've planned group tasks?' (p3/14)

The courage to take risks depended on an ability to ameliorate these risks, to plan for them and a belief that the teacher can always rescue situations in a classroom when things are going awry. This was returned to in other triads where the importance of planning was stressed (see 5.3.1.3 Third triad below).

5.3.1.3 Third triad

Pair	Different
8: Covering a supply lesson using a lesson plan supplied by the absent teacher. 7: Providing feedback for students about their work.	2: Planning a lesson for my favourite class.

The third triad covered the role of the teacher during the planning of, and performance in, a creative science lesson. Well-planned lessons were seen as important in promoting creativity. This was a theme that recurred throughout the conversation. Planning might involve using new approaches, new resources or simply deciding who sat where in the class.

> Whereas this one <the planned lesson> you could plan in maybe a task where they have to learn from each other but you have to provide resources <printed materials or equipment>…' (p4/22)

> Well, you may have had me creating seating plans deciding which learners are going to learn best with each other um…um creativity in terms of the planning and structure so it's scaffolding, I may have modelled, I may have demonstrated a practical in a different way.' (p6/24)

However, while effective lesson planning was seen as a way to stimulate and support creativity in the students it was only part of the issue. Teacher 1 felt she could encourage creativity in her students by the way she conducted the lessons. For example, in the case of the cover lesson, where planning had been done by another teacher, it was still possible to encourage creativity by responding to opportunities that arise - which she described as creativity 'on the spot'.

> 'Um yeah so you can, on the spot, come up with things to make the cover lesson a bit more interesting and give feedback at the same time. Whereas if you're planning your own lesson for your own class you can actually plan more I think… you can take more risks and um … you can … plan for the learning during it rather than having to do it there and then.' (p4/16)

When asked where she felt she would be most naturally creative (the planned lesson or the cover lesson) the teacher was clear.

> 'I think it would have to be in terms of this one, the cover lesson, because it is outside of your specialism … you may have to adapt things very quickly.' (p4/33)

This quote seems to conflict with her expressed opinion that planning was important to ensure students had the opportunity to be creative. However, the creativity she is talking about here is her own creativity, in effect her *performance as a teacher* rather than the creativity exhibited *by her students*. In a carefully planned lesson she can provide opportunities for students to be creative whereas in a lesson outside her specialism, where things might change rapidly, she feels she has to draw on her own creativity to keep the lesson working. When pressed for examples of this 'on

the spot' creativity she gave a number of examples of techniques that could be used anywhere to introduce a creative moment.

> 'This < the cover lesson> would have to be on the spot creativity, with general things that you do might be like to ask kids to write their own questions based on what they're learning because that can be done for any lesson there and then.' (p4/20)

These techniques were described at other times in the conversation.

> 'Students working together and coming up with ideas… um… creating their own questions… their own answers … they're justifying those answers um…You may have had them …' (p6/24)

> 'I let students chose the style they get it across to me in so they can verbalise it, draw it, present it as sentences, bullet points, paragraphs, are they just going to put a load of key words together and then make sentences … you have to be creative in how you let them get it across to you…' (p10/26).

In this, the teacher is a performer promoting creativity. Doing things differently or in a surprising way was seen as important for students' learning and for personal satisfaction for the teacher. When asked later in the conversation if creativity was personally important to the teacher, as opposed to merely a requirement of good teaching, she was unequivocal.

> 'Oh big time! I don't think I could teach if I wasn't able to teach in my way <with lots of creativity and flexibility>.' (p7/31)

Emergent pole	Contrast pole
There are a number of simple techniques that can inject creativity into a science lesson at any time.	Planning lessons can encourage creativity in students by building in appropriate activities.

5.3.1.4 Fourth triad

Pair	Different
3: Attending a science department meeting after school. 5: Facilitating student-centred science projects.	1: Teaching a revision lesson for an upcoming public examination.

The conversation sparked by the fourth triad covered a wide range of ideas. The initial focus was on collaborative working and how creativity can be enhanced by this collaboration whether this is at a science department meeting or when planning for student-centred projects

> 'You can do that <planning lessons> as a group of teachers and creativity will be coming from more than one person.' (p5/17)

> 'So bouncing things off each other other works really well not only within departments but across the school as well. I think it's nice to have inputs from everywhere …' (p5/25)

However, while collaboration was important, the individual teacher was clearly important in generating insights. The teacher makes this clear in her answer to the question 'where do ideas come from?'.

> 'Uh, I think it's experience … starting with your training and watching other good teachers deliver what they deliver. I think it's going to … uh … CPD be it within or out of school. I think it's <where do ideas come from?> … natural … if you go into teaching you are quite a creative person in terms of 'how do I get this across to the kids?' 'Do I model it? 'Do I you know…use play-doh?' 'Do I get out a ruler and start building things with it?' You know, you've just got to think outside the boxing I think we are open-minded in terms of coming up with ideas to make it simpler and stripping things back for the students.' (p5/31)

Being open to new ideas and approaches was seen as creative and central to the teacher personality.

> 'You can't be rigid and boring.' (p6/6)

As well as being open to new ideas and approaches the teacher had to match these to the needs of their students.

> 'I suppose creativity is about adapting something for your students.' (p6/17)

Taking ideas from others was seen as good but they needed to be modified and developed so that the way they were presented reflected the teacher's personality.

> 'Even though you watch, growing up as a teacher, different teachers, different styles, different ways of getting things across how teachers write their questions, how they ask their questions, get verbal feedback … but you still have deliver it with your personality and your … because I don't think the students will have that relationship with you if you don't. I think they know when you're false … and they know when you've not planned for them.' (p7/32)

This notion of trust between teacher and student was seen as particularly important when considering taking a risk with a new, more creative task.

> 'And I thought, you know, are they gonna behave while they do this? Are they going to be able to push themselves where they're creating questions and actually analysing what they've got to give the answer ? So I thought, no I wanna try it. So trust them. And actually it's one of the best lessons ever and they've learnt so much from it that I got two lessons into one. So I think that that was a really creative lesson.' (p8/19)

Being willing to take a risk was seen as central to creativity in science teaching but that risk had to be carefully managed to avoid chaos. Careful planning, and the relationship with the students were cited as factors that helped to ameliorate any dangers. The growing maturity of the teacher as a practitioner meant that her plans were more considered and effective and she could also respond creatively to problems as they arose (another reference to performance as a way to rescue a lesson that might be going awry or becoming boring).

> ‘Whereas now I’m aware of when I am coming up with new ideas and planning things that I have to make sure they’re thought through and I’ve thought about it properly that it’s got maybe 99% chance of working and 1% chance of failing. (p9/19)

Emergent pole	Contrast pole
Creativity benefits from collaboration with multiple inputs from many people.	Individual creativity is more limited than collaborative creativity.
Exciting and off the wall ideas are the sign of creative teaching.	Rigid and boring with no excitement.
Creative activities are matched to the needs of the audience and must be fit for purpose.	If creative activities are inappropriate (not matched to the needs of the audience) they will fail and the trust between teacher and student can be eroded.

5.3.1.5 Free conversation

The conversation then continued without the element cards to get a more free form perspective on the notion of creativity.

The teacher described herself as creative and clearly valued this. She made the point that she taught in a more creative way both because she could (she felt she was creative) and because she had to (the alternative would be demoralising).

> ‘So I think you've got to be creative in terms of how you get things across. I would get bored as well if I stuck to the same things all the time personally within myself and I think I’d just become a bit demoralised if I wasn't creative.’ (p10/19)

Despite the firm conviction that teaching was a creative profession and she personally approached it in a creative manner she wondered if her students would recognise that.

> ‘Students will probably not speak of their activities in the science laboratory as ‘creative’. I don’t think they would verbalise it as that, no. I think they would verbalise it as “Oh, miss makes us do loads of different activities” and they would say that and they’d go “Oh no, miss lets us try different things” I don’t think they’d verbalise it as “we are being creative”.’ (p11/23)

However, after further thought she emphasised again creativity as a central feature of teaching.

> ‘Yeah… <long pause>…. if fact, thinking about it… having somebody question you on it … you’re creative nearly every minute of the day as a teacher.’ (p12/8)

5.3.2 Teacher 2

5.3.2.1 First triad

Pair	Different
2: Planning a lesson for my favourite class. 5: Facilitating student-centred science projects	9: Preparing for an OFSTED inspection.

The first triad focussed on structure and constraints with the emergent pole characterised by open projects which let students explore with the minimal restriction. The teacher explained that students who are unconstrained and exploring issues for themselves are being creative. The teacher's role was to act as a facilitator who supports but does not dominate the students' work. This was a theme that emerged a number of times.

> 'I can let them really go away and use their creativity to … they can go off and do it in their own way.' (p1/33).

> '… discovering things for themselves … it's where my sort of involvement is minimal…' (p3/64)

The contrast pole was about control imposed by an external body, in this particular case OFSTED (the government body responsible for inspection of all state-funded schools in the UK). The teacher explained that a lesson he would be willing for an OFSTED inspector to see would be highly constrained and that he would be much less willing to take risks concentrating instead on the components identified by OFSTED as being indicative of a good lesson.

> 'I have to think about all the things, all the box-ticking things that I have to do for them and it's more constrained because when they come I'm thinking "have I done this? have I done this? have I done this?" rather than thinking about how I could be creative in a lesson' (p2/17)

The OFSTED lesson was also seen as a 'standard' lesson with limited room or desire to do anything different in contrast to a creative lesson where almost anything could happen. When asked what a creative lesson would look like compared with the more pedestrian OFSTED-friendly lesson he was clear. Lessons where multiple solutions to a problem were possible and where the lesson might end up in unexpected destinations, driven by students, were seen as creative.

> 'So, for me… thinking out of the box, using things that I've not thought of, using the … um… discovering things for themselves … it's where my sort of involvement is minimal … but I've given them the framework in order to them to achieve the end goal that I want them to. So I'm sort of … I have a point A and a point B or maybe I haven't got the point B even but I've got this sort of idea of where I want them to go … not necessarily… they might end up at a point C…' (p3/5)

The teacher stressed that when his students were creative he was personally inspired and excited.

> 'It's this sort of journey that they take and that's what really inspires me not the two points in between but how they get there and different mechanisms that I give them to allow them to get to those … to take that journey… And sometimes getting to point C is more exciting than getting to point B… and that thing that you've not thought of … but it's the things that they learn and get in that journey… it's the most important thing I think.' (p3/14)

Emergent pole	Contrast pole
Creativity involves risk-taking in terms of the lesson's desired outcomes and the degree of control offered to students.	A standard lesson with no risks or chances to deviate from the plan is less creative although may still be effective as a lesson.
Creativity creates excitement both for student and teacher as the participants in a lesson stimulate each other.	Lack of creativity generates lessons that are acceptable but boring.

5.3.2.2 Second triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 6: Marking an assessment for GCSE or other public examination.	4: Researching a topic I do not know about but will be expected to teach.

The second triad looked at what happens when the teacher was not immediately familiar with a topic and was being asked to develop their own ways forward. The pair described a predictable, interlocking system where assessment demands mandated revision lessons and revision lessons led towards assessment tasks. The contrast pole was more about what happens when there is no clear mark scheme or revision package. Creativity was seen to reside in the response to this lack of knowledge, explicit direction or structure.

> 'I'll have to go away and research that, there's no mark scheme for it, no framework or structure' (p4/23)

One of the advantages of this lack of knowledge was that it motivated and enlivened the teacher - it made them think.

> 'Because when I'm researching I'm thinking of ideas for the lesson, how I'm gonna create the lesson, how I'm gonna insert this lesson into my teaching, how am I going to do practicals, how am I going to get the kids engaged? So this is my, when I'm going away researching, I'm thinking about all the things that I use within lessons and how I can use that to help the students progress so it's sort of getting me firing and thinking about how I can make it exciting.' (p4/29)

Later the teacher clarified that it was the lack of knowledge and experience that was helpful, even exciting.

> GP OK. That's so… so actually what makes it creative is … just loads and loads of questions, nothing's fixed down, everything up in the air and it's actually quite exciting by the sound of it?
>
> T2 Yeah.
>
> GP Whereas the other end its safe, secure, OK, nothing wrong with it but, you know, it's all done and dusted …

T2 Exactly. Yeah. (p5/1)

This contrasts strongly with the safe, known pathways of the emergent pair about revision where detailed support and established procedures reduce the need for research and consequently engagement:

> ' it's set … got a mark scheme, there's no research involved in it, it's been done…' (p4/16)

Emergent pole	Contrast pole
Too much support and easy solutions tend to reduce creativity.	Lack of an easy solution or immediately relevant prior knowledge can stimulate creativity.

5.3.2.3 Third triad

Pair	Different
7: Providing feedback for students about their work. 8: Covering a supply lesson using a lesson plan supplied by the absent teacher.	3: Attending a science department meeting after school.

The third triad returned to the notion of where the control resides in a lesson. Rather than looking at control in the teacher-student relationship (Triad 1) this triad looked at control in the relationships between teaching colleagues.

Elements 7 < Providing feedback for students about their work. > and 8 < Covering a supply lesson using a lesson plan supplied by the absent teacher. > were identified by the teacher as 'non-creative' because he would not expect to be creative in a lesson he was covering.

> 'My sort of main goal in that lesson would be behaviour management and making sure I'm covering all the bits that the teacher wants me to cover in that lesson as … um … a supply.' (p5/35)

The strategic control appears to reside with the absent teacher who has delegated behaviour management to the covering teacher. It is paired with element 7 < Providing feedback for students about their work. > because, if the teacher was covering outside his specialist area, he would not have the requisite knowledge to provide useful feedback and so would degenerate to simply managing student behaviour. The role was seen as monitoring rather than developing or driving.

The contrast pole was the science department meeting which could be creative, or not, depending on what happened.

> '…this one's < 3: Attending a science department meeting after school> a weird one because its the one that - the reason it stood out to me is that it can be creative and it can be non-creative at the same time that's why it is on its own um…' (p5/19)

The department meeting was perceived to be non-creative when it involved the passive receipt of information but very creative when teachers had chance to engage with new ways to do things as a group.

> ‘Now with this one <3: Attending a science department meeting after school> the reason that its creative and non-creative is um some of the time I’m involved in developing things for the science department things like the Twitters things like the YouTube and, it’s getting teachers excited about new activities and it’s … or there’ll be consultations inside the science department where we discuss an idea and we try and develop an idea. So those sort of meetings are creative whereas the other meetings where, for example, we talk about the Key Stage curriculum or we’re … or some information is being given to us… and its very much no creation at all, you just sit there and you just listen to the information , interpret what’s said or however. So that sort of stands out as the … both creative and non-creative.’ (p5/22)

Emergent pole	Contrast pole
Operating a pre-defined, managerial role within a larger strategic plan can offer limited scope for creativity.	It is possible to adopt a creative role, e.g. developing ideas, when an individual can take responsibility for their own work.

5.3.2.4 Fourth triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 5: Facilitating student-centred science projects	9: Preparing for an OFSTED inspection.

The fourth triad looked at ownership and opportunities. Element 1 < Teaching a revision lesson for an upcoming public examination. > was chosen because it needed an input of creativity to make it work.

> ‘I think revision can be a bind for kids and it lacks creativity.’ (p6/19)

This lack of creativity and interest could be addressed by providing more open-ended or surprising tasks for students. It was also seen to be important that students assumed ownership of their learning to encourage greater engagement in tasks and ultimately success.

> ‘So it’s … they're in charge of their own revision and they know that when they come in how it’s gonna impact their learning so they're gonna struggle in the lesson if they’ve not gone away and done it so it’s making them have ownership of their .. their own revision. And from what I’ve done with that has been so much creativity , so much sort of taking ownership of their revision because they're doing their own thing I’m not

giving them any guidance with it I'm just giving them the tool and the way they use that tool is totally up to them.' (p6/23)

While the teacher downplays his control somewhat, he recognises his responsibility for their general progress and his management of them.

'It's sort of making them do revision without them realising they're doing revision.' (p7/1)

The tasks that make revision activities creative are challenging, open, offer ownership to the student and have multiple possible strategies to develop a range of correct answers

'… there's so many avenues for them to go down to get the same answer … ' (p7/35)

'… it's them creating a problem rather than me giving them a problem and them just telling me the answer …' (p7/19).

These tasks can be distinguished from non-creative tasks which are obvious, simple and algorithmic, usually with all the key components supplied, so that there is no need to explore beyond the worksheet.

'I give them a physics worksheet … they've just got to put numbers in … so I give them the equation…' (p7/12)

The teacher linked active students who can direct their own learning with creativity and excitement (this appears in other triads) to produce a mutually supportive combination. More ownership and creativity lead to greater enjoyment and achievement with less dependence on structure. Highly structured lessons where students have no control or ownership tend to reduce creativity and enjoyment.

Emergent pole	Contrast pole
Active students who take ownership of their learning are more likely to be creative and creative students are more likely to own their learning.	Directed students are less creative and can find the direction offered boring.
Defining and owning a problem rather than being given a simple problem to solve is more creative.	Telling students to respond to a pre-built, immediately soluble problem does not support creativity.

5.3.2.5 Fifth triad

Pair	Different
3: Attending a science department meeting after school. 4: Researching a topic I do not know about but will be expected to teach.	8: Covering a supply lesson using a lesson plan supplied by the absent teacher.

The fifth triad looked at how creativity could be sparked by a need to change or by working collaboratively with colleagues. The need to change was created by modifications to the National Curriculum or other regulations mandated by government or awarding bodies. This was not seen as a bad thing because it generated an impetus for development.

> 'Whereas it can be very sort of … <sigh> …whats the word? … people can get fixed in a rut and if it's there why change it? Why do extra work? Why do this? Why do this? But when I've got a new area from the curriculum its allows me to sort of, you know, "well guys, were starting something new here", allows me to really push something that's more creative or more … exciting for the students.' (p8/23)

Change was seen as good because it stimulated a response and, given ownership, the response could be creative. It would be possible to create new and exciting lessons and activities that were not merely different to the old lessons, in that they tackled new content areas, but better because they were more exciting, accessible and creative. This idea links to Triad 2: the benefit of 'not knowing', where a lack of knowledge actually stimulated creativity.

The creation of these lessons was ideally collaborative. Involving colleagues who see potential problems or options can make the ideas stronger and their implementation more elegant.

> 'Well what about this? What about this? … Creativity for me is not just me creating something (by myself), it's working within the team to come up with ideas about things that I would never even think about … helps me develop my idea.' (p8/32)

Emergent pole	Contrast pole
Change offers opportunities for creativity.	No change makes it more difficult to encourage the effort needed to be creative.
Collaboration improves my creativity and the creativity of others in the team.	Working alone reduces creativity and make the ideas less resilient.

5.3.2.6 Free conversation

The conversation then continued without the element cards to allow more open discussion about creativity and to give the teacher chance to make any extra comments. The insights from this section reinforced many of the constructs from the earlier conversation.

The teacher saw his role as less to do with direction and delivery and more to do with facilitation and support. There were hints, unexplored during the conversation, about the skills needed by students to enable them to explore a topic. The teacher felt that these skills should be taught by the teacher.

Questions could drive a lesson - but finding a question with sufficient interest and depth was difficult. A key characteristic is that it should be apparently easy to answer but lead to greater and greater depth. Students should leave the lesson with questions as well - to provide all the answers is impossible and closes off further thought and exploration. Better to leave some

questions and options open at the end in the hope that students will think about these independently.

Working in teams was seen as crucially important for creativity. It improved the quality and quantity of ideas and stimulated communication of the ideas and insights. The visibility of creativity was also considered important both because it was seen as a part of creativity and to stimulate thinking and creativity in others.

> '…it's the sharing of those ideas, sharing them with me, sharing with others and then from that that sparks creativity because then others think "Oh I didn't think of that", "Oh I didn't think of tackling that question in that way" or even "I didn't think you could do that!" … you know, so it's this sort of it's a feedback as well so you need that feedback in a lesson where everyone sees what everyone … because there's no point in being creative if no-on else gets to see it or … is it worth being creative if you can't convey your ideas as well? It's being able to convey them to other people. So it's alright having it on paper … having it wherever … but unless you can share that idea have you been creative? I don't think you have … because you … I think to be truly creative … if you've got a piece of beautiful artwork that's locked away. Well that's not creative because no-ones gonna see it, it has to be shared with the world for it to be truly creative.' (p10/10)

5.3.3 Teacher 3

5.3.3.1 First triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 6: Marking an assessment for GCSE or other public examination.	5: Facilitating student-centred science projects

The first triad emphasised the effect of public examinations on the teacher's role and the impact that this had on their, and their students', creativity. The sense was clear: examination pressure controlled the nature of the activity in the classroom,

> 'Essentially most of my teaching is preparing students for an examination, so … Lesson: assessment: intervention. Lesson: assessment: intervention.' (p1/15)

> 'You teach it, you assess it , you teach it, you assess it and it goes round in that cycle.' (p1/33)

> 'We're almost giving every student access to almost every question that has ever been written on a topic by an exam board.' (p1/18)

It was accepted that this system works well, in terms of preparing them for examinations, but when something unexpected appears 'spanners come flying out of the box.' (p1/26) and things start to break down. Other comments about the impact of examinations also seemed negative.

> ‘6 <Marking an assessment for GCSE or other public examination> and 1 <Teaching a revision lesson for an upcoming public examination>, stifle creativity in some respects because whilst you can be creative with the way in which you teach a topic to try and allow a student to learn it you are limited by definition of what the topic is.’ (p2/20)

The tone in the quote above is very different to the more positive phrases used about student-centred projects.

> ‘An Extended Project Qualification with Year 13 which they can… they can almost do some … almost university standard research into an area of science.’ (p2/8)

The Extended Learning Project is an AQA qualification that ‘allows each student to embark on a largely self-directed and self-motivated project. Students must choose a topic, plan, research and develop their idea and decide on their finished product.’ (AQA, 2015). The increase in creativity and performance seems to be attributed to students having more control compared with the rigid content demands of standard public examinations. The key to student creativity seemed to be ownership and openness.

> ‘Yes. Card 5 <Facilitating student-centred projects>. Because this gives the student a lot more ownership of their science …uh … and the public examinations, whilst there are arguments to say they are necessary, you know … that’s a separate issue uh they … they are very tight in terms of the science they need to ultimately know about. Whereas, student-centred science projects have a lot more scope for their imagination and investigates … investigating whatever it is that they wish to investigate.’ (p2/2)

Furthermore, the increase in creativity in the students generates a corresponding rise of creativity in the teacher as both adjust to changing circumstances.

> ‘I think the student is being a lot more creative in 5 < Facilitating student centred science projects> and the teacher is almost having to match their level of creativeness to… to enable that next step of learning to occur.’ (p3/15)

The teacher drew a distinction between this creative practical work and some of the more structured approaches which he suggested tended to stifle creativity. Practical work in this case refers to laboratory exercises using scientific equipment (e.g. laboratory glassware, measuring instruments) and consumables (e.g. chemicals, biological specimens). The sense in which the term was used emphasised ‘demonstration practicals’ which exist to demonstrate, illustrate or clarify topics in a practical experience that have already been covered in theory lessons.

> ‘Whatever practical we do they they’ll have to see that if you switch the light off the plant doesn't grow. They’re not finding anything out by that practical, you're just demonstrating really what the effect of that variable is on that … and that, in some respects, stifles creativity.’ (p2/34)

Emergent pole	Contrast pole
The teacher as expert, delivering content defined by examination boards in a manner that closely links to requirements of the assessment vehicle. The student, and teacher, is passive.	The teacher as a coach or facilitator supporting students as they explore areas in a more open-ended manner is more creative

5.3.3.2 Second triad

Pair	Different
2: Planning a lesson for my favourite class. 4: Researching a topic I do not know about but will be expected to teach.	8: Covering a supply lesson using a lesson plan supplied by the absent teacher.

The second triad focussed on issues of control, comfort and the teacher's willingness to take risks. The teacher seemed to feel that, when planning or researching for his own purposes, he was in control and, even if working in new areas, there was a sense of rising to the challenge. This was a positive experience that reinforced his perception of himself as a creative, dynamic person who took risks to deliver good learning experiences for their students.

> '…that <4: Researching a topic I do not know about but will be expected to teach.> is actually forcing me to be quite creative when I teach that because I've gotta actually find a way that I teach myself at the same time as I'm teaching these students and we're very much collaborating in each others' learning at this point.' (p4/27)

> 'Absolutely take more risks yeah… uh… because if you don't take that risk you'll never know if it works.' (p5/18)

This level of personal control and involvement stands in distinction to the comments about covering a supply lesson planned by someone else where the teacher claims their own personal creativity would be limited.

> 'It's someone else being creative and … I suppose I'm having to … I suppose I accept their creativity or reject their creativity depending on my own confidence and my own comfort in what I'm being asked to do.' (p4/1)

They may also be teaching outside their preferred specialism and might even feel somewhat annoyed about having to do the cover at all and these will also tend to reduce the desire, and options, for creativity.

> 'I have a knowledge gap here <teaching outside the teacher's subject specialism>.' (p4/10)

> 'If I've been given it in the morning then I'm not going to be creative at all, because I'd probably still be rather cross about it and … uh … you know… it's gonna be case of 'right this is what you have to do, get on with it.' (p6/23)

Descriptions of this end of the triad focussed on negative factors such as risk (including actual physical risks due to work in a science laboratory as opposed to the risk of a lesson not working),

poor student behaviour and lack of familiarity with students. All of these would tend to reduce creativity.

> ‘If you are taking that unqualified, dangerous risk, if you have not assessed the impact of that risk then you are at serious risk of an incident occurring that could cause major consequences for the student and for yourself as a professional.’ (p6/17)

> ‘If you don’t know the group personally but you know that Rory in the corner there is quite capable of being you know uh … a horrible little boy and that …uh…. you know Katie in the corner here and Rhianna in the corner there do not get on, paired working is not gonna work.' (p5/33)

Emergent pole	Contrast pole
The creative teacher as a risk-taker, formulating their own plans, exploring new topics and ‘collaborating’ with students whilst giving the material their own ‘personal slant’. A sense of aiming high with high stakes for teacher and students.	Teacher operating to someone else’s plans and with a sense of survival rather than success, not always knowing exactly what to do or how to perform to the standards they wish to experience.
Working within a comfort zone consisting of established content knowledge and possessing good key teaching skills which believe improve student learning.	Working outside normal area of expertise with unfamiliar content and novel teaching techniques that require skills the teacher does not have or believes are ineffective.

5.3.3.3 Third triad

Pair	Different
7: Providing feedback for students about their work. 9: Preparing for an OFSTED inspection.	3: Attending a science department meeting after school.

The third triad looked at creativity in restricted or controlled environments (preparing for OFSTED and marking students’ work) compared with more open, collaborative environments (the science department meetings). At one end there was a sense that creativity was possible in a collaborative environment with shared goals and power.

> ‘This <3: Attending a science department meeting after school.> gives you that perfect opportunity to be creative because you are thinking of ways in which you can enhance the performance of your department ultimately … and … and even in a business meeting there’s an extent to be creative because you're trying to find a way to make the process more efficient… that ultimately is creativity …’ (p7/8)

At the other, more restrictive, end a system was being imposed and, while the system might not be inherently bad, its imposition created problems.

> ‘We are actually jumping through the hoops <a particular method for recording student progress> that SLT have set for us.’ (p7/14)

> ‘So… so I do think you need that … some structure in place but at the same time it has to be a structure that you mutually agreed on . It can’t be a structure that has

been imposed by somebody in an office who doesn't actually teach the subject… because what works in maths doesn't always work in science, what works in science certainly doesn't work in art.' (p9/18)

Whilst accepting that the imposition of a system from outside can be wrong, and it was clear that the teacher thought the specific examples cited in the conversation fell into this category, he also had some issues with unbridled creativity. Here creativity seemed to be linked more to license than anything else.

'If you just allowed the creative process to occur unchecked then we've got a very serious danger, even within the science department of this school, of having a bunch of very, very good physiologists, a bunch of very, very good analytical chemists and a bunch of extremely competent geophysicists … but we'd have nothing in between because we'd teach to our own… uh… bias and our own comforts.' (p9/14)

There seemed to be two issues concerning this teacher: creativity going 'wild' and becoming counter-productive with no controls or creativity being inhibited or eradicated when imposed systems and procedures dictate what teachers are allowed to do. These pressures were explored further in the discussion around Triad 4.

Emergent pole	Contrast pole
Systems imposed from outside, often for other purposes, tend to reduce the room to develop appropriate solutions internally.	Agreed systems to support the efficient running and creative development of the department help to build creativity and protect against chaos.

5.3.3.4 Fourth triad

Pair	Different
7: Providing feedback for students about their work. 5: Facilitating student-centred science projects	4: Researching a topic I do not know about but will be expected to teach.

This triad revisited topics covered earlier about student-centred projects and feedback as being creative.

'As we've discussed a student-centred science project where they are … in effect they're they're creating their own learning' (p10/17)

'And we've discussed the idea of feedback being very creative' (p10/21)

However, he agreed that, at times, the school systems could override this creativity by imposing rules and limitations as described below.

One limitation to the freedom to be creative in Extended Learning Qualification (a GCE Advanced-Level qualification from AQA) was that the teacher may not be familiar with the material that needs to be covered. Being 'vastly out of my knowledge field' (p10/29) created a lack of confidence for

this teacher which he claimed could inhibit creativity. This is akin to performance anxiety as it relates to the teacher's concern about their role in the project.

The conversation continued with a slightly different concern about creativity: that it could potentially create over-specialised, obsessive characters who did not know when to stop or did not have the skills and knowledge needed to manage in wider society (see also the similar comment about teachers in Triad 3).

> 'Then the whole process actually becomes much more creative to the point where perhaps where it can become too creative because you keep going round in … almost a spiral going up the staircase and you never actually quite reach the top because there's always a bit further that you can go uh…' (p11/5)
>
> '… and so I don't like to stifle creativity I'd love to be able to say to my students 'Be as creative as you want, go away the world is your oyster' but ultimately as well if you keep on that creative process and keep on and keep on … how are they gonna pay for it? How are they going to develop those other skills they need to be competent reasonable adults in a reasonable society.' (p12/12)

This is a slightly different worry to the performance anxiety identified above and the demands of the syllabus seemed, in this instance to be a helpful bulwark against this tendency.

> '… they actually have to learn the behaviour of Group1 metals because AQA says so.' (p12/34)

This part of the conversation seemed to describe creativity as a sort of license to 'follow your dream' almost to the point of self-destruction, it is creativity without bounds or purpose which could lead to people who were irrelevant in that they did not have the 'skills they need to be competent reasonable adults in a reasonable society.' (p12/12)

To further emphasise the dangers of creativity the conversation then turned to the example of eminently creative people who were anything but a force for good.

> 'I'd love to say creativity isn't dangerous … then I think you look at some of the most villainous or sort of dangerous people we've had on the Earth and they're probably some of the most creative people in order to create these ideas in the first place.' (p13/5)

Emergent pole	Contrast pole
Creativity involves degree of license. This needs to be tamed to make it socially acceptable and productive or it runs the risk of leading to obsessive, damaged or even dangerous personalities. The desire, and aptitude, for creativity does not override the rights of the rest of the group.	Creativity can be a force for good - but only when it is channelled into socially and personally productive paths. This implies a sense of control rather than license.

5.3.3.5 Fifth triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 8: Covering a supply lesson using a lesson plan supplied by the absent teacher.	6: Marking an assessment for GCSE or other public examination.

The fifth triad returned, again, to issues of external control as it played out in this teacher's role as an exam marker.

> 'I am extremely limited by what the Chief Examiner has decided is the correct answer to a particular question.' (p14/13)

> 'And it seems that the creative process that the students in that particular school have gone through hasn't really come to much because … uh… every one of them is writing down a particular key word to a particular answer and I'm having to mark the statement wrong because it's not the key word that the AQA has decided upon as the correct answer even though, as a human, I know exactly what they're on about' (p14/23)

This was 'creativity', in the sense used by this particular teacher, that had, apparently, failed because it has not generated the technical term approved of by the 'Chief Examiner'. This seemed to suggest that creativity was more about freedom and license, perhaps being slightly 'off beat', rather than a valid way to perform in the school context.

Later in the conversation, while discussing a revision session the teacher gave the impression that creativity could enliven a tedious task like revision. This is creativity as entertainment, creativity that makes an unpalatable topic more interesting and creativity that is not dangerous or disruptive.

> 'I'm trying to be creative in the way in which we explore revision … it's … revision's got to be fun and engaging for the student otherwise they won't revise.' (p14/32)

However, within seconds the danger of creativity had reasserted itself in the conversation. Creativity as entertainment could so easily become creativity as the path to examination failure.

> 'You are actually stifled by that need to make sure you teach exactly, if you like, the statement that's going to be on the mark scheme because if you don't, then your creativity has been for nothing and you have …. you have perhaps made yourself feel like a better human being for an hour and a half but you haven't perhaps helped these children get to where they need to be…'. (p14/34)

This suggestion that creativity, and the fun it can foster, has to be subservient to the specific needs of the examination instrument was not a criticism about the *amount* of content to be covered, a common complaint amongst teachers, but a protest about the strictures of the system which required *a particular phrasing*, the 'key word' (p14/23), for an answer to be considered mark-worthy. The comment above also revealsed some of the teacher's inner turmoil as it drew a

distinction between feeling ‘like a better human being’ <being creative and delivering fun for the students> and being effective by getting the children ‘to where they need to be’ <with presumably the answer the examiner is expecting>.

This tension was further explored in a sporting metaphor drawing out the idea that, while a game is played to very definite rules, a good team and coach can work within these creatively to secure a good result. The players on the pitch have chosen to play and chosen to be limited by the rules of the game. However, in schools some rules are be enforced even if the teacher was not involved in drawing them up.

One of the reasons for this ‘playing by the rules’ was that it ensures fairness to all candidates sitting an examination as this conversation shows:

> T3 We’ve come across people who have been … a little bit *too* creative <implication that help may have been offered to students that was clearly outside the spirit of the examination regulations> in how they’ve played to the rules!
>
> GP <laughs>
>
> T3 In … when it comes to playing to the rules and that’s … that also has its issues at times. You know, we all… whilst we’ve not set these rules we owe it … I owe it to the students in a school in Barnsley <not Teacher 3’s school> to play by the rules
>
> GP Yes.
>
> T3 Uh… as they are. And if I don’t play by those rules then the whole system … the whole system goes to pot. (p15/29)

This conversation illustrates this teacher’s idea that creativity could be seen as an opportunity to ‘play outside the rules’ or on the edge of what is acceptable and that this would not be fair to other people involved in the same system. There is a sense, supported by comments throughout this conversation, that creativity could easily be interpreted as license and that this was not always a good thing. The first half of the conversation seemed to be very much about the negative effects of over-structured systems and lack of freedom while the second half was dominated by the teachers worries about creativity as license - and so being in need of control.

Emergent pole	**Contrast pole**
Creative solutions recognise and abide by a set of rules for the benefit of the whole system and all people affected by it. Creativity is acceptable in some areas, e.g. ‘fun’ but might be questionable in other areas, e.g. rules for a game.	Slavish acceptance of system rules can limit creativity - sometimes in negative ways as the rules are not sufficiently flexible or sophisticated to take account of all circumstances.

5.3.3.6 Free conversation

The conversation then continued without the cards. The insights from this section reinforced many of the constructs from the earlier conversation.

While creativity is ‘a force for good’ (p16/9) the realities of the situation in schools meant that creativity had to be managed to deliver an education that met the needs of students and teachers

in a system constrained by examination and curriculum pressures. Furthermore, one person's creativity must not be allowed to negatively affect other people. There is no overriding 'right' to be creative in all circumstances and at all costs. This picks up again the 'creativity as license' idea from the second half of the conversation.

The conversation was much more nuanced than some of the others where creativity was seen much more positively (see Teacher 2). This might be because of Teacher 3's role as an examiner (with the necessary focus on grades) and as a Head of Science (with responsibility for management of the department and students' progression to university and further study).

5.3.4 Teacher 4

5.3.4.1 First triad

Pair	Different
6: Marking an assessment for GCSE or other public examination. 8: Covering a supply lesson using a lesson plan supplied by the absent teacher.	2: Planning a lesson for my favourite class.

The first triad reflected a clear distinction between an open situation where there was freedom to 'do essentially whatever you like' (p2/19) and the more restricted options of the GCSE marking or supply cover. This was emphasised again later in the conversation when the other end of the construct was described as 'closed off'.

> 'That …that <Element 6: Marking an assessment for GCSE or other public examination + Element 8: Covering a supply lesson using a lesson plan supplied by the absent teacher > is very much closed off to being able to do what you want that <Element 2: Planning a lesson for my favourite class> is very much open to being … doing what you want …' (p2/34)

This sense of 'my way' as opposed to 'their way' turns up in other triads as well, for example in Triad 2 and Triad 6.

> '… that is limiting … the school wants you to do it their way.' (4/29)
>
> 'I just want the freedom to do … I like to be able to do what I want … <laughs>' (p12/16).

Element 2 was also explicitly described as 'creative' reflecting the teacher's perception of both the presence of options and the lack of predefined structure in lessons where they were in control..

> 'Because you've got a sort of free rein with that <2: Planning a lesson for my favourite class>, it's creative and you can do essentially whatever you like um with that …' (p2/19)

Compare the open, free end of the construct with the mark scheme which was described as being very closed and constrained terms both in terms of having to do it and to comply with external systems as a way to complete the task.

'…marking, you've got to do it, follow the mark scheme there's no being creative about it you've got the mark scheme…' (p2/21)

This seems to imply a structure to live within, a system to follow. This is further reinforced when it is conceded that, with the second member of the Pair, Element 8: Covering a supply lesson using a lesson plan supplied by the absent teacher it only became creative when the teacher stepped outside the control, beyond the established system.

'I suppose there's a little bit of creativity involved in that you can go off script if you are comfortable with the topic but if it's outside science then <laughs> no chance of that!' (p2/14)

This comment reveals both a sense of constriction and the option of going 'off script' in certain circumstances where the teacher feels powerful enough. This idea was revisited in later triads where creativity was often seen as doing something different or unexpected.

Emergent pole	Contrast pole
A detailed procedure can reduce creativity. The teacher is reduced to a deliverer of an experience, designed by others, rather than being the creator of it.	A more open situation requires the teacher to be more active in constructing the experience offered to the students.

5.3.4.2 Second triad

Pair	Different
2: Planning a lesson for my favourite class. 9: Preparing for an OFSTED inspection.	7: Providing feedback for students about their work.

The second triad explored the differences between planning and performance in terms of freedom to manouvere. At the planning stage many options remained open - until the teacher made decisions. The teacher clarified this distinction between planning and preparing for the lesson and providing feedback at the end of it.

'I would say I'm thinking about how I'm going to be creating everything at this stage <2: Planning a lesson for my favourite class.> and that feeds through to … way through to that <7: Providing feedback for students about their work.>… so that… almost as though my creativity is sorted by here (at the planning stage).' (p4/3)

There was some talk later of things changing in the lesson because 'things go off-track' (p4/6) but this further reinforces the idea that the creative element exists at the start - effectively when the 'track' is created or mapped out.

'I've already thought about it at this planning stage and I know where I'm gonna end up and how I'm gonna get there and this is what we're taking … and OK sometimes things go off-track … when I'm creating the task, whatever may be, I'm thinking about how I'm going to mark it, how I'm going to assess it …' (p4/4)

'So my… my sort of … again it goes back to that sort of freedom being able to do what I want to do comes in here <card 2:Planning a lesson for my favourite class.> …

this is what's going on right at the end even though we're nowhere at that stage yet…' (p4/10)

When questioned about how much freedom the teacher had in providing feedback to students he went on to describe how a marking policy could restrict options in an unhelpful way.

'So I feel, yeah, that … that can be … that is limiting that school want you to do it their way when, in actual fact, it can be done very well in a more creative, more accessible way.' (p4/29)

Emergent pole	Contrast pole
Most creativity exists at the start of a process when more options are possible. This is about inspired planning.	The latter stages of a process are closed down by the decisions made earlier and occasionally external forces. This is about a competent performance.

5.3.4.3 Third triad

Pair	Different
6: Marking an assessment for GCSE or other public examination. 1: Teaching a revision lesson for an upcoming public examination.	5: Facilitating student-centred science projects.

The third triad tackled control by, and of, the teacher. The teacher was seen as controlled, to some extent, by the syllabus and even by the students.

'These two <6: Marking an assessment for GCSE or other public examination. And 1: Teaching a revision lesson for an upcoming public examination.>, although one is marking and one is teaching a revision lesson … you're limited on content .. uh… we've got to get through this, this, this in both…' (p5/12)

'Yeah, uh… it's … it's almost 'Oh let me tell you about this amazing thing.' 'Do we need this for the exam, sir?' 'No.' ' Can we not talk about that because it's just gonna confuse me.' (p5/21)

Here the students are arguably controlled by their perception of the importance and demands of the examination - a utilitarian approach that seemed to cause the teacher some issues and restrict his opportunity to be creative - or to encourage creativity in his students.

At the same time, the teacher recognised that student creativity was linked to his relinquishing of control.

'So with the student-centred projects then…in my head I'm thinking that's maybe something lower down the school where you've got a bit more freedom … freedom again…<laughs> yeah, essentially they're doing something that is very …um… open, they can take it which way they want, you're almost relinquishing control at that point, you're letting them do what they want to do in a slightly structured manner but it's … it's more of an over to them type thing … um…' (p5/7)

Here the teacher clearly saw students exercising more control over their work and making more decisions about the direction it is going in - within broad constraints. Also note that the teacher was '*relinquishing* control' and '*letting* them do what they want' (see quote above) implying that ultimate power remained with the teacher who almost *relinquishes* control and *lets* the students but reserves the right to take back control at any time should the lesson stray beyond certain parameters set *by the teacher*. This control-freedom issue turned up regularly in the conversation with a link to increased creativity at the freedom end of the spectrum. The teacher equated freedom with the opportunity to be creative; when he enjoyed this freedom he felt more creative and when his students enjoyed more freedom he felt they were more creative. However, sometimes their choices (see the quote above from p5/12 about sticking closely to the needs of the examination) caused him some discomfort. To his disappointment, they exercised their freedom to be tightly focussed on their examination requirements rather than engaging in creative wonderings. He reinforces this point explicitly later.

> 'Now, how you deliver that examination content … then we are able to do quite creatively but you don't want to go too far off or too wide around that topic because actually the bit they need to know is the bit they want to know… the bit they want to do.' (p5/23)

When asked to describe the characteristics of the kind of creative lesson that might occur the teacher offered two descriptions. One revolved around students being active while the other concerned students doing something different or unexpected. Underlying both was student enjoyment.

> 'But then we also do … um … activities where they've got to do it so … some of these facilitating idea, so this is what you need to know, here's some information, textbooks, internet whatever …. see if you can pull that together, that information, and find out for yourself.' (p6/2)
>
> '… just as many different ways of them essentially learning the same, not necessarily the same thing, but the same topics but doing different ways …' (p6/6)
>
> 'Well yeah… doing the … trying to make it as fun an environment by as many different methods and the students going 'I've never done this before' Good! That's what I want to hear! <laughs>' (p6/12)

Emergent pole	**Contrast pole**
Excessive control limits creativity. This control can reside in imposed rules or be self-imposed by adherence to larger goals (e.g. I need to do this to get my exam pass).	More personal control and options promote creativity.
Novelty, surprise and fun (for students and teacher) are characteristics of a more creative lesson.	More of the same and a level of boredom are characteristics of a less creative lesson.

5.3.4.4 Fourth triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 2: Planning a lesson for my favourite class.	3: Attending a science department meeting after school.

The first card identified for the fourth triad was card 3 about science department meetings. This selection was followed by a long pause and, with questioning, the key issues appeared. As far as this teacher was concerned the science department meeting focussed too much on providing information and checking on adherence to administrative procedures. This was seen as not conducive to creativity and compared badly with the meetings at the teacher's previous school which had always included something more inspirational.

> '… there are certain things that we … almost got to get through in the meeting … that are all sort of 'are we on track for this?'' 'have we put this into place?' 'what's been done with this?'. It's almost the … making sure everything's on track to where it supposed to be going to … it is the admin-y type of catch-up with all that's going on. Now, if I compare that to my last school, as part of the department meeting there was always a sort of teaching and learning section to it … uh… and one member of the department would be asked to bring something to the meeting… of 'I've done this in the past few months. I found it really good, I found it enjoyable, students really got on with it. This is what it is, you can try it.' (p7/9)

This seemed to hit two issues, creativity being enhanced by ideas 'it gives that little spark of … a new idea' (p7/30) and the sense of collaboration, either in department meetings or while preparing lessons in the workroom (a room where all the science teachers had a desk and easy access to the prep room where technicians managed the resources, equipment and chemicals used in lessons) as he stated later in the conversation.

> 'It's that planning stage, that's the bouncing ideas off other people stage, sitting down in the workroom and saying 'I'm doing this lesson,' and John goes 'Oh yeah, I've come across this, you might…' and that is… it's the sharing ideas that can happen at this stage <Element 2: Planning a lesson for my favourite class> again…um… sat in a group with other people and those ideas bouncing around.' (p8/16)

One issue seemed to be that merely doing the same as everyone else was not considered creative but taking other peoples' ideas and input and somehow making them your own was creative.

> 'Yeah, I think well maybe I could use that… not like they did but… I could use that, I could do that like this.' (p7/29)

Emergent pole	Contrast pole
Sharing ideas with others or developing ideas from others to give them your own 'flavour' is creative. Meetings that spark off these discussions and thoughts support creativity.	Activities devoted to passing on information or being told what to do do not tend to encourage creativity.

5.3.4.5 Fifth triad

Pair	Different
8: Covering a supply lesson using a lesson plan supplied by the absent teacher. 1: Teaching a revision lesson for an upcoming public examination.	4: Researching a topic I do not know about but will be expected to teach.

The fifth triad concerned the confidence to change a course of action, to go 'off piste' when the teacher desired it. At the emergent pole, the teacher placed lessons where he was comfortable and confident - either because the lesson was easy to do (the revision lesson) or he had been given a complete lesson plan (the cover lesson). Although these could have been viewed as restrictive in other contexts he drew out the supportive aspect of them.

> 'These are together because they are very much know what you're doing, just get on with it type topic. So even if it's a cover lesson out of specialism if you're supplied a lesson plan if you're told what you're doing you know what to do… um… doing a revision lesson, you've done the whole topic, you're really familiar with what they need to know for GCSE. It's very much a you know what to do, crack on with it type, very much a get on with it type lessons.' (p9/17)

This contrasted quite markedly with the alternative where the lesson involved breaking new ground.

> 'I don't necessarily know the topic but you know what you've got to do… if that makes sense? This, research a topic <Element 4: Researching a topic I do not know about but will be expected to teach. > I don't know about is …um…. like the unknown side of things… so if it's something I don't know about it's … might be don't understand… something I don't understand… I need to get to the stage where I do really understand it before I can deliver it.' (p9/24)

At one end there is confidence and comfort while at the other is uncertainty and threat. This might lead to a lack in creativity at the apparently more open end of the contrast as the teacher opts for safety.

> 'If it's a topic that you don't know about that you've got to research… are you going to be comfortable enough with it to try something different when it comes to teaching it? So… yeah… so… for example an A-level topic that … um… I'm not familiar with, that I'm … is outside of what I can … or outside of what I can do at degree level I'm going to have to do the research and the lesson is probably going to be quite simplistic and quite teacher-led.' (p9/33)

This was a surprising result in some ways because the teacher seems to be valuing support (detailed plans, known topics) over freedom and novelty (a new topic to research and plan lessons for). This was not a commonly held view amongst the other teachers involved in the study. When questioned he confirmed this, stating that the overriding issue here was of comfort and control.

GP Now you see these here, 1 <Teaching a revision lesson for an upcoming assessment.> and 8<Providing feedback for students about their work.>, some people might say are very restrictive but what you seem to be saying is actually they're not restrictive they're just supportive because I reserve the right to go off piste if I feel like it…

T4 Yeah, yeah.

GP Whereas here <4: Researching a topic I do not know about but will be expected to teach.> where some people would say the sky's the limit you're saying "No I don't want that because I like to be confident before I take the risk". Is that fair?

T4 Yes. Yes.

GP And so the difference between these really is about your feeling of strength and power and control?

T4 Yes! <laughs>

GP Sorry, I don't mean that in a pejorative way…

T4 No.. yes… I know what you mean.

GP You feel really comfortable here and think "Right, I'm really gonna kick ass here and…" '

T4 I'm in control, I'm not in control. Yes. Yes

GP OK right, so, in control what? In control of the kids? In control of yourself? What? In control of the content? Is this about…

T4 Just in control in general of the whole … yeah… about … yes…I'm in control… it's about my performance essentially . I'm in control what's going on I can go off…Here <card 4> I'm less confident so I'm not necessarily gonna go off to one side until I'm happy with the basics…

GP Right.

T4 You mentioned going off piste… it's a … it's a skiing analogy. These runs I'm happy with I know where they're going so I know if I go through those trees on the lefthand side I know where I'm going to pop out from. I don't know where this red one is going to end up so I'd better stay on it and find out whats at the bottom before I cut though the trees and across a cliff… (p10/23)

Teacher 4 was the youngest teacher in the study and had qualified only two years before the conversation took place. His greater desire for support compared with other older members of the sample group might be explained by his relative inexperience.

Emergent pole	Contrast pole
It is easier to feel comfortable, and be 'in control' in a situation when you are familiar with it or have detailed instructions. This can lead to greater creativity.	Being outside your comfort zone can inhibit your willingness to take opportunities to be creative. The performance of the task can override your desire to be creative, expressed at other times, forcing you to opt for a safe, if simple, treatment.

5.3.4.6 Sixth triad

Pair	Different
9: Preparing for an OFSTED inspection. 6: Marking an assessment for GCSE or other public examination	2: Planning a lesson for my favourite class.

The sixth triad returned to motion of freedom and options contrasting cards 9 and 6 with card 2.

> 'So 9 <9: Preparing for an OFSTED inspection.> and 6 <6: Marking an assessment for GCSE or other public examination> make me think of jumping through hoops … they are … you've got to do this, you've got to do this, you've got to do this… so it's quite literally jumping through hoops.' (p11/27)
>
> 'it's almost like those hoops are bigger and further apart…(pointing to card 2: Planning a lesson for my favourite class.). (p11/32).

There is a difference here in the degree of control (bigger hoops further apart are easier to get through than small hoops close together) rather than total control or its complete absence and again picked up his relative comfort with a degree of control compared with some other members of the study group.

The conversation then continued as the teacher created a group of five cards which he felt illustrated a significant point about his idea of 'jumping through hoops'. The five cards are:

Pair	Trio
9: Preparing for an OFSTED inspection. 6: Marking an assessment for GCSE or other public examination	1: Teaching a revision lesson for an upcoming public examination 2: Planning a lesson for my favourite class. 5: Facilitating student-centred science projects.

In the pair (9 and 6) are his 'jumping through hoops' lessons with extensive, and, in this teacher's opinion, unwelcome interference from external systems. In the trio (1, 2 and 5), by comparison, were lessons where the outcomes were clear but there was considerably more opportunity to 'do what I want to do' (p12/15).

Emergent pole	Contrast pole
More detailed, more frequent controls are perceived as more restrictive and less likely to support creativity.	Targets in themselves do not have to reduce creativity if there is sufficient room to manoeuvre in how the targets can be approached.

Free conversation

Putting the cards away the teacher was asked if there were any other aspects of creativity he would like to mention. He volunteered immediately that he enjoyed being creative.

> 'that's why I got into teaching… it wasn't to mark papers it was to do this creative thing.. it was to be…<creative>.' (p12/29)

When asked about what this 'creative thing' looked like he described a lesson in his previous school into the advantages and disadvantages of nuclear power. It was a required topic on the GCSE but with added local relevance given the closeness of the school to Sizewell B nuclear power plant. He split the class into two groups, supported research into the topic by students and ended with a class debate with both sides presenting their cases. The positive points he drew out of this experience included limited structure and control by himself, greater student autonomy and a sense of them becoming involved and active.

> 'So they had time to do some research and then really just left them to it … and… but set it up in a structured way so that they would get there but they felt very much like I was doing nothing … um… and… let them run with it.' (p 13/12)

He also identified that he had to be brave.

> '…because it was a risk, it was a class where it could go completely wrong and they could have spent their time on YouTube looking at videos they didn't need to and the debate could be 'Well, I like nuclear power because my dad says so' or 'Me dad works there' or 'I don't like nuclear power because my dad's got a farm and they're buying that off him.' (p13/17)

Ultimately, the lesson delivered what he wanted to hit his target.

> 'It just worked really well and I just came out going 'well I know every single one of them has got the arguments for and against they need for their GCSEs.' (p13/15)

The decision that this lesson 'worked really well' depended on the students' engagement but was also validated by the ever-present need to cover the material they needed for their GCSEs.

> 'Yeah, it's got to work. So you could make… you could be as creative as you want .. you could go completely off on one with a creative lesson but if it doesn't get the job done then you can't necessarily do it too often <laughs>.' (p13/35)

5.3.5 Teacher 5

5.3.5.1 First triad

Pair	Different
4: Researching a topic I do not know about but will be expected to teach. 5: Facilitating student-centred science projects	9: Preparing for an OFSTED inspection.

The conversation began by the teacher talking about planning as a way to link the two cards in the emergent pole 'both have elements of planning' (p2/5) but it soon became apparent that the planning was simply a means to do something new and more interesting.

> 'It's bringing in, trying to bring in something that's new and current … something which is in the news … build that into a lesson which may already be planned but you're looking to improve … or you'll do it different from previous years… previous class.' (p2/8)

The novelty and improvement described here was clearly viewed as an important part of creativity in that the teacher went on to say:

> 'So there is that kind of… sort of… gathering your thoughts, getting some creative juices flowing, trying to do something different trying to do something new …'. (p2/14)

Another issue that grew out of this part of the conversation was the notion that creative activity tended to be interesting and potentially disruptive (causing change) whereas the alternative pole was mundane, repetitive and pedestrian. Describing OFSTED inspection preparation the teacher was clear than it was more about admin than creativity.

> 'I've done three or four OFSTED inspections … All of them have been … uh… not entirely functional but more functional … um … preparing evidence of things which is there … just collating evidence, maybe documenting things that in a specific form that you already have in a different form … um… and making sure everything in order essentially. Doing a bit of housekeeping. Doing a bit of tidying up.' (p2/20)

So, whereas creative activity was thoughtful and disruptive leading to new and exciting things the contrasting pole was pedestrian and functional leading to backwards-looking documents that catalogued, in a specific form, activities that had already happened. Describing the typical inspection for private schools (Teacher 5 worked in the independent sector) the teacher said that although the inspectors are more flexible they still had targets ('certain things') some of which were described as 'mundane'.

> '…require certain things to be done and that is often mundane … um…. uh…. however essential to demonstrate that you can pass an OFSTED inspection.' (p3/1)

Emergent pole	Contrast pole
Developing new, exciting and improved activities - an emphasis on the potential for change and improvement.	Reporting on existing practice, often in a highly structured format requiring some 'housekeeping' work.

5.3.5.2 Second triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 6: Marking an assessment for GCSE or other public examination.	5: Facilitating student-centred science projects

This triad centred around the degree of freedom enjoyed by the teacher and students. At one end the room to manoeuvre was considered limited and the process was controlled to some extent by the activity itself

> 'I guess there is a feedback mechanism there <Element 1: Teaching a revision lesson for an upcoming public examination>… where you have to prepare them. If you know how to mark you can prepare them slightly better than than if you didn't. So there is a … there is a loop there which … the more practice you have the better you are at approaching those exams and … the more times you see the results of exams, marking assessments you …uh… hopefully would be better at preparing your students for them …' (p3/29)

The quote above described a heavily regulated, even if self-regulated, system. It was later contrasted with the student-centred projects.

> 'Whereas this <Card 5: facilitating student-centred science projects.> has …uh…uh… uh… not quite a carte blanche but we have, in this school, the opportunity to … to … to go off the syllabus a little bit because we have slightly more time to do that so we … so we do things which are not on the syllabus and we do them because they are interesting, engaging … uh … fascinating, amusing sometimes, but they are different.' (p4/1)
>
> 'Yep. They've got freedom. … one student's just set up a little web …web area for the… for her chosen animal. One of them's done just … just a traditional poster to display on the wall. Others have one little Powerpoint presentations… but yeah, it's whatever… some of them have done models …so…. it's to get them to …. do whatever they want.' (p4/29)

While these projects allowed some freedom for the student and the teacher the students cannot do exactly what they want. Rules and guidelines remained to focus student activity.

> '…it <the student-centred project> is … centred towards possibly preparing them for these things <public examinations>. Why do we do them? Not just completely abstractly we're doing them based on a curriculum or on a syllabus but they are, yeah, there is that freedom to be … to be different, you know, … to do something else.' (p4/18)

Also the demands of the assessment scheme were made very clear to the students.

> ‘And they're given a mark scheme, so the mark scheme … we publish our mark schemes on our Virtual Learning Environment … they've got access to the mark scheme so they know what they're being marked on … there is a marking criteria and a marking grid. So they … they could … have complete freedom to do what they want as long as they gear it towards a potential outcome which is the mark scheme…’ (p5/8)

So, the triad compared directed situations with rules imposed without explanation or consultation with more open situations where, even though guidelines still exist (e.g. a mark scheme which specifies the curriculum content area of the eventual project and time limits for the project performance), there was room for students to explore and make choices. One end was seen as measured, structured and open to improvement with practice whereas the other was more open, allowing some negotiation within boundaries so that students could follow their enthusiasms (not always wisely).

> ‘They <the students> have a certain time frame to do it <their project> so they won’t just go mad and spend hours and hours and hours and hours on it. However some do <laugh>.’ (p5/5)

Another aspect of the student-centred projects concerned the degree of collaboration within the science department to facilitate these projects. Although the students could choose their projects they were given guidance which had been developed at a departmental level. This focussed the projects somewhat and may have allowed the teachers to relax a little and give students more freedom because they knew that they would not stray too far into inappropriate or unproductive areas?

> ‘Um…. we…. uh…. as a department do some communal ones <student centred projects>… so there’s one on the wall here which is a … a project to research an animal. So the students … we all do it rather than me just come up with my own science project. So within the constraints of a departmental policy… a departmental project … there’s freedom to roam around with that but ultimately you're still doing the same kind of things … um…. hopefully ….’ (p4 13)

The role of the science department, whether it is supportive of creative work or simply about administration, is explored by both Teacher 5 and 6 who work at the same school. They expressed very different views on this topic. Teacher 5 (see Triad 3) was broadly positive about the department meeting seeing it as supportive and an opportunity for collaboration whereas Teacher 6 (see Triad 1) regarded it more as a formal, non-creative meeting dominated by administration.

Emergent pole	Contrast pole
Detailed instructions and procedures reduce creativity and demote activities to merely functional or mechanical. This is a job.	Options allows creativity to flourish bringing with it greater variety and quality of output and, potentially, enthusiasms where the student does much more than is required (or possibly wise). This is a joy.

5.3.5.3 Third triad

Pair	Different
3: Attending a science department meeting after school. 7: Providing feedback for students about their work.	9: Preparing for an OFSTED inspection.

The third triad considered the potential to change and improve. It compared, at one end, tasks which allow some room to improve, some modification of their procedures and chances to share better ways to do things with colleagues against tasks that are more rigidly structured with no 'wriggle room' (p6/24). The comments about OFSTED were unusual in that most of the teachers questioned in this study were negative about OFSTED inspections in every sense. The issue for Teacher 5 was not the inspection itself but the perception that the procedures were too restrictive. Teacher 5 was much less negative about OFSTED than most of the others in the sample. Underlying the distinction was that while marking and attending meetings could be seen as mundane there was always the possibility of doing them differently, perhaps better.

> 'that <points to Element 7: Providing feedback for students about their work> could be conceived to be fairly straightforward… fairly mundane, fairly ordinary … routine … um… but actually, could actually be quite interesting to get new methods like … of feeding back … and how do you do that? By sharing good practice at a science department meeting.' (p6/17)

This opportunity to have an effect, to make a change in the process and learn from each other was characteristic of the pair (cards 3 and 7) and notably absent from the OFSTED end where the only option was compliance.

> 'This is what they (OFSTED> ask for so it's what they want you to do … and you have to do it.' (p6/35)

The problems caused by limited or no change was seen to have effects on both students and teachers. The teacher did not want to be doing the same thing for 15 years and valued inputs from a range of people to make their work more interesting and effective.

> '… in teaching you get stuck and you get set in your ways … and you can end up doing exactly the same thing for 15 years … um… however, that's not how it should work and with…certainly with different people coming from different backgrounds you've got different experiences and you've got different access to different things and … and trying new things is part of keeping you fresh as well as your … your curriculum.. teaching your students …' (p7/25)

Emergent pole	Contrast pole
Chances to change the procedures and processes in a task while living within the overall purpose. Engaging with the task, and with others doing it, changes both he person doing the task and the components of the task itself.	The processes and procedures cannot be changed reducing the operator to a mechanical component rather than a creative, thinking contributor.
Working with others can bring in perceptions and suggestions from others which will improve all. Science Department meetings, at their best, support this.	Working in isolation to solve an individual problem reduces creativity and personal development by locking out perceptions from others.

5.3.5.4 Fourth triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 8: Covering a supply lesson using a lesson plan supplied by the absent teacher.	2: Planning a lesson for your favourite class.

The conversation around Triad 4 tackled two issues: normality versus innovation and confidence versus a degree of uncertainty.

The initial discussion clearly signalled that Elements 8 <Covering a supply lesson using a lesson plan supplied by the absent teacher.> and 1 <Teaching a revision lesson for an upcoming public examination.> tended to produce normal or mundane lessons whereas the chance to plan a lesson for your own class offered the potential for creative excitement and novelty.

> ‘And again I think there’s a certain amount of normality, routine, ordinary going on here < 8: Covering a supply lesson using a lesson plan supplied by the absent teacher; 1Teaching a revision lesson for an upcoming public examination.> and potentially a lot of creativity in number 2 <Planning a lesson for my favourite class.>’ (p8/34)

If creativity produced excitement and novelty and promoted personal growth for both teacher and student why was it not a characteristic of every classroom? The conversation here identified two possible problems: permission and confidence. The teacher explained how both tended to reduce his options.

> ‘… because it’s not your class and … you need to… you need to … do what they want rather than what you want. Because it’s not your class, you don't have ownership.’ (p11/2).

It was not seen as appropriate for a cover teacher (a teacher covering a lesson for an absent colleague) to come in and overturn existing lesson plans and topics. At one point the teacher also defended their own right to insist that things are done ‘their way’ by supply teachers because cover teachers could introduce errors or disrupt the class’ permanent teacher’s learning plan.

> ‘I wouldn't necessarily want a non-specialist coming in telling my students something which is even … you know… a wrong spelling … because often it’s the thing that they fix on and they can’t spell it for the rest of their life! And if they’re told something and that’s not how you would do it or how you would say it then again it can often cause more problems than it’s worth.’ (p11/9).

Equally, when providing cover for a colleague the same teacher felt outside their area of control and lacking in confidence. In an earlier comment in the conversation about covering a geography lesson the teacher reduced his role to, almost, ‘babysitting’ where half the lesson’s outcomes would not be achieved.

> ‘If I was doing a geography lesson I would use what they'd said and it would just be … do this. So, you're limited, you're in a straightjacket there and you are just essentially, not babysitting, but its it’s classroom management and, at best, if they achieve half the goals that the teacher set I’d be surprised …’ (p9/10)

Yet later in the conversation the teacher admitted to having a qualification far in excess of the content for the relevant lesson.

> ‘I mean I did A-level geography so again I could teach GCSE geography class, I’m pretty certain of that, however it’s not my place to. And often teachers don't want to . They want a classroom management …’ (p11/4)

Even within the sciences there was a nervousness about taking classes outside the teacher’s specialism.

> ‘Certainly key stage 2 and 3 …but not 4 and 5. No, not because I’m not capable it’s because <pause> … perhaps yeah. I've been a science teacher for … 5 or 8 years and a biology teacher for ten years. So the specialism has taken the majority of my time … and you lose those skills. So it could be yeah….just confidence but … um… a lot of schools are now asking members of staff to diversify into more than one subject fortunately here we just teach our specialism.’ (p11/29)

With regards to creativity, these two issues (lack of confidence or permission) the teacher seemed to imply that they tended to reduce engagement with a class and hence options for creativity.

Emergent pole	Contrast pole
Obeying the rules and fitting in can be justified in certain circumstances but will tend to restrict creativity if a teacher is outside their area of specialism.	To be creative teachers need to feel in control both of the students’ learning pathways and the details of the content and skills to be covered.
Creativity can be tempered in certain circumstances and this is appropriate and helpful.	Creativity can be problematic to a teacher when someone interferes with their plans, even if creatively, and changes things.

5.3.5.5 Fifth triad

Pair	Different
4: Researching a topic I do not know about but will be expected to teach. 5: Facilitating student-centred science projects	8: Covering a supply lesson using a lesson plan supplied by the absent teacher.

This triad compared a chance for novelty and excitement with normality and established ways of working.

> 'Again just highlighting some of the things we've already mentioned. That's … <8: Covering a supply lesson using a lesson plan supplied by the absent teacher.>… is formality and you're just serving a function there you're not teaching them you're just maintaining the *status quo* and getting a bit of work done whereas here <4: Researching a topic I do not know about but will be expected to teach. and 5: Facilitating student-centred science projects> you have got the option to do something new, interesting, find out stuff and … um … get the students to relax a little bit … to get them to … engage with something that's new to them as well as perhaps to yourself.' (p12/15)

The distinction between 'maintaining the *status quo* and getting a bit of work done' with the option for novelty, interest and the chance to 'engage' could not be clearer. When asked to explain the meaning of 'relax' the teacher claimed that the pressure students were under through constant examination and periodic tests could reduce the room for actual engagement with the subject being studied. The school recognised this as such a significant problem that they had a system to make space for the most able students to go on trips to get chance to think and be stimulated beyond the normal classroom diet.

> 'We take them on trips that we reserve for those that would benefit from it rather than <all students> … we're going on a trip. We give the opportunity to those who are at the top of their game.' (p13/4)

This revealed another significant difference - that much of the more pedestrian and functional work was justified by the demands made by external agencies (public examinations, content specified by curricula) whereas the justification for the more creative end of the triad was endogenous. It grew out of the teacher's personal interests and was only available when the demands of the other end had been met. This insight draws on other comments through the conversation where the teacher spoke of creativity and the option for new experiences and activities as being personally valuable

> 'You'd be getting out something that's new to you and if you've got time to do it justice … which is often not the case… but you're researching something that's interesting in your … you've chosen to do the subject so… if you're asked to teach it then you've gotta do it but it's nice to get some new information, some new ways of looking at things , new skills … some new resources… um… and again that refreshes you as a person as well as the way your students see you.' (p13/15)

Emergent pole	Contrast pole
More creative work is interesting, often novel and personally significant offering valuable opportunities for development.	Less creative work is formal, functional and often justified by external forces. Simply a job to be done as efficiently as possible.

5.3.5.6 Free conversation

The conversation continued without the use of the cards to get a more open perspective on the notion of creativity. This short section of the conversation centred on the need for time and freedom to be creative and an acceptance that creativity is demanding - as is teaching.

> 'I suppose it's having time to do things. If you don't have time to do things then creativity goes out the window.' (p13/30)

> 'If you're being asked to do too much then something has to give and so perhaps the creativity of finding new things to do and bringing things to the table … you know… doing something different … all those things tend to get suppressed a little bit…uh….I know that if I worked every minute of every day I still wouldn't have done everything that I wanted to do … so you have to draw a line somewhere and say 'It ain't happening' and that the reality of managing a family, a life, a job, a career if that s the right word …' (p13/35)

5.3.6 Teacher 6

5.3.6.1 First triad

Pair	Different
2: Planning a lesson for my favourite class. 9: Preparing for an OFSTED inspection.	3: Attending a science department meeting after school.

This conversation began with the teacher reinforcing the idea that, when they do plan, they plan to make it interesting - and that means being creative.

> 'You're obviously going to try and make it interesting .. you're going to try and be creative and put lots of differentiation activities in it … you're gonna try and engage the pupils…' (p2/6)

The teacher then went on to describe a 'well planned' lesson in terms of the structures included 'a beginning, a middle, a plenary' (p2/11) and the activities that she would do 'a QA <question and answer session>at the end' (p2/14). All of these things would be recognised by OFSTED as a good lesson structure and the teacher saw no distinction between OFSTED and her favourite class. Both audiences deserved a creative response on her part.

> ‘I think that’s very similar … favourite class you'd always try really hard to make it good and for OFSTED you're gonna try really hard to make it good.’ (p2/15)

The contrast pole concerning the after-school science department meeting was very different. Here she claimed that the group (her teaching colleagues) tended to be passive, keen to leave and merely receiving information.

> ‘There’ll always be somebody chairing it, usually the Head of Department, and we can chip in with our bits you know and he’ll just ask us questions like, ‘Well where are you with this class?” and “Make sure that everybody’s at the same position.” Make sure we all know when the tests are. Make sure when were doing the Christmas test. … you know, that kind of thing…’ (p3/1)

> ‘And you always have list … and an agenda… what you've got to do… and there is AOB at the end but by the time you've got through the rest of the agenda you're getting to AOB and thinking ‘I’ve got to get home now’ … …we don't always have time to be creative unfortunately which is very sad.’ (p3/15)

The meetings were also often timetabled for the lunch break which seemed to reflect the relatively low importance attached to them by the department.

> ‘Well we don't always have them after school we have them at lunch times cause in our department a lot of people live a long way away so it’s not really fair to say they have to stay at school for two hours.’ (p3/24).

Despite these negative feelings about the department meeting the teacher did suggest that they could be sources of, and support for, creativity.

> ‘I mean we do ‘sharing of expertise’ but it’s not … we don't always have time to do that in a meeting after school… it would be more discussing where we’re going and what’s the new objectives for the new practical course or, you know, what meetings have people been to have anybody got any feedback from anything that they've been doing or you know we don't always talk about our lessons properly. Which is a shame really but… we don't always have the time.’ (p2/25)

The emergent pair reflects a chance, even a requirement, to be creative whereas the contrast pole shows a situation where creativity, although possible, seems to be pushed off the agenda by other, more pedestrian, tasks.

Emergent pole	**Contrast pole**
Given time, creativity can produce interesting, exciting and engaging activities. When I have the power to choose I choose creativity.	Creativity can often be pushed out by other, more managerial and pedestrian, tasks or by simple lack of time.

5.3.6.2 Second triad:

Pair	Different
4: Researching a topic I do not know about but will be expected to teach. 5: Facilitating student-centred science projects	8: Covering a supply lesson using a lesson plan supplied by the absent teacher.

This conversation revisited the notion that, given the chance, a teacher will always try to be creative. In the specific instance of researching a new topic she was particularly clear.

> 'If I have to research … I try and be … I'm going to try and be creative aren't I? Because I'm going to try and find out things I can do to make it interesting…' (p4/9)

Her commitment to 'interest' is common with science projects.

> '… and when you're looking at science projects you're doing the same sort of thing aren't you?' (p4/11)

The link between creativity and a 'good' or 'interesting' lesson flowed through much of the conversation and is in distinction to covering the supply lesson where there were no options for change and no requirement to 'produce' the lesson. Indeed, in many ways the supply lesson was an imposition so the teacher felt no responsibility or desire to be creative.

> 'You're less likely to <be creative> … and more likely to think "Well I've got work to do and I need to mark" … so you hand out the work to them and say "Look this is my free and I need to mark … so, you know, you need to get on with this and I'll have to get on with my work". You're less likely to be interactive as well with the pupils in those kind of lessons.' (p5/4)

A supply lesson could also be outside the teacher's normal area of expertise which reduced their confidence about being creative.

> T6 Yeah! <laughs> So now you've got to teach Latin and I'm what? I don't even know any Latin!
>
> GP *Amo, amas, amat* …
>
> T6 Yeah! Yeah! So, you're going in and you just … there's a lesson plan stuck to the desk and you've just got to do it no matter what it is. And you can say to them, 'Well I don't really know what I'm doing but if you need any help I can try… uh… but you can't really plan for that <card 8: supply lesson>, this <cards 4 and 5> you can do more planning and research where this you can't… it's a spur of the moment thing. Do this please! What? (p4/25)

There was a sense throughout the conversation that the teacher would be creative when she wanted to be (with her own class, in science club, preparing for OFSTED) but was happy to opt out of creativity in other circumstances and just complete the prescribed tasks (attending a science department meeting, covering a supply lesson).

Emergent pole	Contrast pole
Being creative is the default position when planning lessons, there is a constant bias towards producing something that has interest, engagement and excitement for students. This requires time and skill.	When time is unavailable or when working in an area of relative ignorance creativity is reduced and survival becomes the key driver.
When I want to be creative I will be. It is a choice I make.	Sometimes I do not feel the need to be creative. I may want to do something else instead.

5.3.6.3 Third triad

This conversation began with one triad but soon it became apparent to the teacher that the initial choice of elements was confused and the triad was revised. Both versions are given below.

Initial triad

Pair	Different
6: Marking an assessment for GCSE or other public examination. 1: Teaching a revision lesson for an upcoming public examination.	7: Providing feedback for students about their work.

Revised triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 7: Providing feedback for students about their work.	6: Marking an assessment for GCSE or other public examination.

The conversation began with talk of 'serious' work which involved pubic examinations.

> 'So these two <6: Marking an assessment for GCSE or other public examination and 1: Teaching a revision lesson for an upcoming public examination> relate to public exams … which you treat it slightly differently really, don't you… it's a bit more serious…' (p6/27)

The first pair (cards 1 and 7) related to external controls, for example public examinations and syllabus specifications. Then the triad elements were re-sorted and marking (card 6) was isolated as the most 'serious' element on the table.

> 'Marking … it's slightly more serious because obviously you've got to submit it to the exam board. So you're set… we've got more of a set of rules there haven't we than you have for the teaching a revision… teaching a revision lesson is more creative because it's … it's up to you isn't it? How you deliver it and we all deliver things in different ways don't we … so it depends upon how you are as a teacher isn't it?' (p6/34)

This <6: Marking an assessment for GCSE or other public examination.> was then compared to teaching a revision lesson which was possible to do it in a variety of different ways which reflected

the personality of the teacher. The 'seriousness' of the marking activity appeared to depend on external, unchanging constraints.

The chance for a personal involvement was reinforced with a series of examples of ways in which the teacher embeds her approach.

> 'I try and make it fun and write things and chat to them.' (p7/3)

> 'I'm not quite like that. I try to make it a little more creative. So we play little games and quizzes, try and make it a bit more interesting.' (p7/7)

The distinction here was between personal choice and imposed procedures. The procedures were perceived as complicated and demanding.

> 'That <card 6 Marking an assessment for a GCSE or other public examination> you're going to be much more rigid aren't you? Your probably going to have to do it on a screen … send them back the information and, you know, it'll be like, well you can't get this wrong and this has to be right and you know you're constantly following rules and lists … I know the chemistry one's awful! Sometimes you can have more answers you know… you can have like one question and there can be like 20 answers!' (p7/17)

The distinction was reinforced as the teacher talked about her approach to using drawings. These were regarded as creative and she explained that as a youngster she saw herself as creative because she could draw well.

> 'I could have gone down the arty route… was very creative and I used to draw … I'm very good at drawing … I love …. I'm not as good now because I do less practice … I used to be really good…' (p9/16)

The use of graphics for instruction was also seen by this teacher as a sensible approach. They believed that some students would understand topics more effectively when they were given drawings rather than textual explanations.

When pressed to distinguish between creativity about science and creativity in science the teacher identified practical work as creative. The creativity flowed from inventing practicals for students to do which she claimed she enjoyed and did on numerous occasions.

> 'I suppose you… your practicals (practicals designed by the teacher but done by the students) are quite creative aren't they? Your practical lessons … where you invent … I tend to invent quite a lot… I'm quite good at, I tend to say 'Right, let's do this practical and I've never done it before and I'll invent a practical. Ha! I kind of say well put this in this and see what happens.' (p10/22)

Emergent pole	Contrast pole
Creativity involves room to change things and invent new ways to do things - that are often more interesting and exciting.	Highly structured procedures reduce the space for creativity - and can be boring for the teacher as well as the students.
I like to be creative and recognise my own creativity in terms of 'arty' work (diagrams, drawings) and a willingness to invent new ways to do things.	Where there is no invention there is little creativity.

5.3.6.4 Free conversation

The conversation continued without the cards. The teacher talked of her favourite teacher who presented history with drama and excitement. The emphasis was on delivery and performance. These were the lessons she remembered as being fun and interesting. She recognised her teacher as having great deal of knowledge but also the ability to get this across in an interesting and exciting manner and she seemed to equate this with creativity. Creativity to this teacher appeared to have a strong element of entertainment, performance and artistic work.

5.3.7 Teacher 7

5.3.7.1 First triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 2: Planning a lesson for my favourite class.	6: Marking an assessment for GCSE or other public examination.

The teacher began by claiming that with Elements 1 and 2 they would want to make the sessions more 'interesting' which they equated with more creative.

> 'Um… 2 <Planning a lesson for my favourite class> and 1 <Teaching a revision lesson for an upcoming public examination> both would involve trying to think of some… well me wanting to make something more interesting or making it … I don't know … you can't say more … creative.' (p1/30)

> 'Yeah, so this…yeah make it more creative… so this if you were trying to plan a lesson for your favourite class or teach a revision lesson both of them are … trying to make something totally more creative… to be more creative …to be more interesting, effectively, um…' (p2/2)

These comments revealed the teacher's view that creativity made a lesson more interesting, that he could choose to be creative and that it involved an effort. The notion of effort is picked up again later along with the proviso that this extra time, and effort, depends, to some extent, on the expected response of the potential class.

> 'You're more likely to spend the time being creative in terms of planning a lesson.' (p2/12)

> 'They <the favourite class> will appreciate the time you spent doing it and it will make it a … yeah … more successful experience' (p2/13)

Even revision, which is often seen as tedious, 'they just hate revision' (p2/15) can be enlivened by some creative planning which is the teacher's responsibility.

> 'You have to continually try new things in order to …uh… attempt to get them to learn as well as possible really and do as well as possible…' (p2/16)

This is summed up in the suggestion (see quote above p2/2) that teacher creativity often manifests as an interesting and engaging lesson.

Element 6 <Marking an assessment for GCSE or other public examination.> however was viewed as an activity with no potential for creative interpretation because of the controlled nature of the desired output. The teacher felt that he could make it more interesting or 'creative' because its nature requires strict adherence to rules with no option for improvement. There was a sense of being trapped by the demands of the mark scheme - only compliance was required from the teacher.

> 'The assessment one … it's either right or wrong… there is no black and white … no grey … all black or white … nothing in between …' (p2/5)

Emergent pole	Contrast pole
Creative activities tend to be interesting and offer a variety of possible ways forward. These generally requires more time and effort than non-creative approaches.	Non-creative activities offer very limited or no options in terms of the processes required to complete them or the nature of the final outcome. They can be easier to operate than creative activities.

5.3.7.2 Second triad

Pair	Different
5: Facilitating student-centred science projects 7: Providing feedback for students about their work.	3: Attending an after school science department meeting.

The conversation around this triad began with comments about creative activity producing variety.

> 'So you're not going to end up with 30 identical projects as it were…' (p2/31)

The after-school science department meeting was seen in a very different light.

> 'I think there's generally an agenda behind any science department meeting so there's not really a great deal of creativity… there's always options but rather than …um… yeah… the solutions already exist … they're there to be chosen from …' (p2/35)

Creativity was seen as a source of novel, multiple possible solutions whereas the contrasting end involved guided or managed choice from a smaller number of limited, pre-existing solutions.

Exploring characteristics of more creative activities in detail the teacher talked of students being able to make choices noting that this often improved performance,

> 'So we do extended writing projects … that's the same thing you know where they've got some criteria but they can do what they want with it pretty much.. um…and that means that a lot of them will do something that's above their normal kind of standard of work …' (p3/15)

The teacher's view that the option to choose between a variety of possible output was significant for motivation and engagement and was supported by the observation that the quality of the work was higher when options and multiple solutions are possible.

The teacher stressed that, when providing feedback, the activity was creative in order to be appropriate and targeted which again was contrasted with the more mundane science department meeting which appeared to drive all teachers down the same route.

> 'It's the same kind of thing trying to come up with questions that are creative … are tailored to whatever they … whatever you have observed in their books or in a project …' (p2/33)

When questioned, the teacher went on to describe creativity in terms of creativity being 'an add-on to stuff these days' (3/26) and gave the high level of content to cover as the reason for this low importance. The only solution was to assume the students would do extra work at home to provide the space for more creative endeavour.

> 'There is purely … you know … a massive amount of content so it tends to be more things that are outside school so they will go home and prepare a piece of extended writing or they'll go home and make their model cell or whatever in the way that they want … you know… they've got free rein to do what they want . Whereas in a lesson it's I've got 7 lessons to teach these set 14 things so…' (p3/27)

The teacher accepted that the content load mandated student activity that might be less creative but worried that this approach may not improve learning in depth. When questioned if non-creative approaches were simply more efficient the teacher was somewhat ambivalent.

> 'I think … um time-efficient yeah but I'm not entirely sure I go into entirely with efficiency … this may be more efficient time-wise but not more efficient in terms of what the student learns …' (p4/4)

Emergent pole	Contrast pole
A variety of novel options and products produced with many of them exhibiting the characteristics of good work.	A limited number of pre-existing solutions reviewed and a choice made that often appears to be driven by factors of compliance rather than excellence.
Creative activity can be less efficient in covering pre prescribed content but offer deeper involvement with the material and potentially deeper understanding.	Creative approaches are probably not necessary or appropriate where transmission of a simple set of content in a given time is the key driver.

5.3.7.3 Third triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 8: Covering a supply lesson using a lesson plan supplied by the absent teacher.	4: Researching a topic I do not know about but will be expected to teach.

The conversation here rehearsed many of the topics from the previous triad. Key to the distinction was the difference between being forced to fit into an existing pattern or approach compared with freedom to explore more freely. Most of the conversation revolved around the restricted aspect of the choices in Elements 1 <Teaching a revision lesson for an upcoming public examination.> and

8 <Covering a supply lesson using a lesson plan supplied by the absent teacher.>.

Firstly, to fit into someone else lesson plan was difficult.

> 'If I'm ever given any kind of supply lessons… we very rarely do that these days but uh… I can't just teach what somebody else has handed to me … um… I don't I don't … I struggle to understand someone else's thought patterns and thought processes.' (p4/18)

The boundaries provided by work created by others was a major problem.

> 'There are hundreds of resources that you can get off TES <Times Educational Supplement website which has a large catalogue of learning resources> or whatever… but it's very rare that I'll just be able to teach that lesson as it's been handed to me or I'll be able to use that resource as it's been handed to me.' (p4/32)

The implication was almost that the teacher was *unable* to use these resources or plans. When pressed, the teacher explained that while it would be possible to teach with someone else's resource and plans they preferred to work things out for themselves.

> T8 I choose not to use it because I'd rather do something myself.
>
> GP Right. OK, so this is about … this construct which is the thing you use to separate these things seems to be about choice and control?
>
> T8 Mmmmm…
>
> GP And options whereas here you're in an uncomfortable position because you're being driven down a particular route
>
> T8 Yeah
>
> GP That … there's nothing wrong with it <resources or lesson plans supplied by others> …
>
> T8 No no …
>
> GP You'd rather do it your own way … whereas here <4: Researching a topic I do not know about but will be expected to teach> all bet's are off
>
> T8 Yes… yeah that that's yeah… it's entirely down to me isn't it? (p6/4)

Creativity involved and required choice actively engaged with by the practitioner. This was not simply choosing an item from an existing menu or list, it was a choice to make something using your own ideas and preferences.

Emergent pole	**Contrast pole**
It is difficult to engage with lesson plans or resources produced by other people because their thought processes may be different and there is a preference to do it in my own way.	Creative work generates level of engagement which reflects the commitment involved in engaging in it. The output reflects an aspect of the creator.

5.3.7.4 Fourth triad

Pair	Different
1: Teaching a revision lesson for an upcoming public examination. 9: Preparing for an OFSTED inspection.	2: Planning a lesson for my favourite class.

Up to now much of the conversation had been about the teacher's desire to be creative, the benefits of creativity for student interest and learning and the improved outputs from creative as opposed to non-creative work. This triad focused on the risks involved in seeking to be creative. To be creative involved taking a risk and the willingness to take this risk will depend on the context and class. In situations where an obvious 'success' is required and a 'failure' could be costly (e.g. the OFSTED lesson or a revision lesson) the teacher would be less likely to take a risk.

> 'The outcome has to be something that is successful so I think you're less likely to take a risk with what you do… you know … it's a bit less likely to be … it's more likely to be something tried and tested … um, I don't think I'd ever be willing to …prepare a lesson unless its something they've done before.' (p6/22)

The favourite class, by contrast, offered a more forgiving environment that would allow a more creative approach. While it might be possible to be creative in demanding circumstances the teacher suggested that they would be unwilling to take that risk,

> 'I'm sure.. you know you could be … you could produce an outstanding lesson potentially by being more creative but … it's easier isn't it… it's just … it's less of a gamble to do something that's been tested … less creative …' (p7/4)

Emergent pole	Contrast pole
Creativity involves taking risks and in some instances the possibility of 'failure' means the risk is not taken.	Tried and trusted is not seen as creative - but is safe.

5.3.7.5 Fifth triad

Pair	Different
2: Planning a lesson for my favourite class. 5: Facilitating student-centred projects	9: Preparing for an OFSTED inspection.

This triad explored the teacher's notion of creativity exhibited by his students. Up to this point the conversation had largely revolved around the teacher as creator, the opportunities to do this and the pressures that prevented it from happening. In this triad the conversation looked at the creativity of students and emphasised that it is something that can be encouraged and valued in certain circumstances.

> ‘Uh, 5 <Facilitating student-centred projects> and 2 <Planning a lesson for my favourite class> is … where I’m far more likely to want them to be … the pupils to be… creative um… you know … and deliberately so …’ (p7/27)

However, in other circumstances (e.g. in lessons observed by OFSTED inspectors) the choices necessary for creativity might be curtailed.

> ‘You know I would give three choices of what they might perhaps do in an OFSTED lesson I wouldn't ever give them any kind of free rein to do whatever they chose I suppose.’ (p7/31)

Putting aside the cards the characteristics of student creativity were explored further. Creativity was seen as involving novel activities, for example making models of biological structures or molecules using fabrics, pipe cleaners and sponges. These were seen as creative because they involved the students making a representation that meant something to them - something that was personal to them. In some ways, the more idiosyncratic the better.

> T7 Some of the more able students will end up … will be the ones that replicate something that’s absolutely identical to what it … to what they've seen previously so they're creating a plant cell that is a full model made out of plasticine or whatever and un they’ll be absolutely perfect but the there’ll be the child with a sponge and some pipe cleaner stuck and in actually in terms of modelling they'd be more … they'd been more creative in what they think that those parts of that cell are like so .. so…’
>
> GP So more creative in what way?
>
> T7 Uh more creative in …
>
> GP What have they done more of?
>
> T7 They've tried to go beyond what they've … you know the model that they … or what they’ve been told haven't they? they're trying to … make something … make more sense because it’s what it would represent to them or… It’s like a child’s drawing isn't it you've got a five year old if you ask her what she's drawn its ‘that’s you!’ … why is it me?’ well that’s hair and that’s an eye’… it’s the same kind of thing isn't it … their perception of what’s there and their understanding of what it means… it’s not important whether it’s like me or not… that’s what they see and it makes sense to them … in the same way if they're trying to model a cell or a part of a cell or whatever as long as it represents the right thing to them and improves their understanding of what’s important to them it doesn't really matter if it makes sense to me or not or they can justify what they've done. (p8/29)

‘More creative’ here seemed to be about making a personal meaning rather like a child’s drawing.

> ‘It’s like child’s drawing isn't it you've got a five year old if you ask her what she's drawn its ‘that’s you!’ … why is it me?’ well that’s hair and that’s an eye’… it’s the same kind of thing isn't it … their perception of what’s there and their understanding of what it means… it’s not important whether it’s like me or not… that’s what they see and it makes sense to them …’ (p9/6)

The reference to 'that's what they see and it makes sense to them' could be seen as problematic in one light if 'what they see' and the sense that they 'make' might lead to misconceptions. The conversation however did not address this issue. What seemed to be more significant to the teacher was the freedom offered in this situation compared to other tasks where heavy supervision tended to reduce personal involvement. There is a sense of his pain and frustration in the quote below.

> 'And we do get observed more and more we are scrutinised more and more which means that …uh… there's more and more pre-prescribed ways of doing the job … constantly trying to well, produce lessons that somebody else will see as good.' (p9/28)

Emergent pole	Contrast pole
Creativity produces material that is personal, potentially idiosyncratic, and unexpected. There is a sense of students going beyond the task set.	Where a process is heavily structured and scaffolded creativity is reduced and the final product is not as rich as the alternative, more open tasks.

Later in the conversation, and not specifically about the cards chosen for this triad, the teacher talked about the feeling of being constantly observed and nudged into following more and more detailed departmental guidelines:

> T7 … and we do get observed more and more we are scrutinised more and more which means that …uh… there's more and more pre-prescribed ways of doing the job … constantly trying to well, produce lessons that somebody else will see as good'
>
> GP Produce lessons that are safe and … tick the right boxes?
>
> T7 That's right its a box ticking thing yeah it's not a … yeah … it's … they don't want us to be robots but at the end of the day there's more and more of 'right, these are the colours you should use your Powerpoint slides …. this colour is for if they're doing … if they're reflecting and it's it's the same thing… the remits of what you are doing are getting smaller and smaller and smaller.
>
> GP And does … this is making creativity more difficult?
>
> T7 It's making it more difficult for us to be creative in what were doing as you don't want to do something that would be perceived as a poor learning experience … um… and it means that we offer less opportunities for pupils to be creative for the same reason now the …if there isn't an obvious outcome in terms of learning then its not acceptable … not acceptable… (p9/28).

This reinforced the sense that the teacher felt he trapped in a system that enforced rules from outside and consequently reduced his ability to be creative and respond to the needs of his students as he saw them.

Free conversation

In the final minutes of the conversation the teacher reiterated their belief that creativity was important, but that sometimes this creativity might not be visible to others who might regard it as a 'diversion' from the job of teaching.

> 'Creativity is a big part of Blooms taxonomy isn't it? It's on there… up there right at the top … but its whether somebody perceives that what they're doing as being creative or a diversion from what they should actually being achieving and it … you can't rely on who walks through the door seeing it the same way as you do or seeing it … well the way that the pupils do…' (p10/15)

5.4 Construct listing

Table5.3 which follows lists all the constructs produced by the teachers. These are listed by Teacher along with construct poles (Emergent and Contrast), the teacher (T), the paired elements (P) and the Different element (D) CNo. is the construct number used in future analysis and refers to the teacher/construct, so 1.5 is Teacher One's fifth identified construct.

Table 5.3: Full construct list

T	P	D	CNo.	Emergent	Contrast
1	2, 7	6	1.1	Creativity depends on, and generates, options and having a range of possible ways forward.	No freedom to deviate from provided plans makes creativity impossible and unnecessary or irrelevant.
1	1, 4	9	1.2	Risks are an essential part of creativity - to explore new approaches. These risks can be managed by careful planning and personal performance and flexibility during the lesson.	External direction can make the risks beyond the teachers control which tends to reinforce safe behaviour.
1	8, 7	2	1.3	There are a number of simple techniques that can inject creativity into a science lesson at any time.	Planning lessons can encourage creativity in students by building in appropriate activities.
1	3, 5	1	1.4	Creativity benefits from collaboration with multiple inputs from many people.	Individual creativity is more limited than collaborative creativity.
1	3, 5	1	1.5	Exciting and off the wall ideas are the sign of creative teaching.	Rigid and boring with no excitement.
1	3, 5	1	1.6	Creative activities are matched to the needs of the audience and must be fit for purpose.	If creative activities are inappropriate (not matched to the needs of the audience) they will fail and the trust between teacher and student can be eroded.

T	P	D	CNo.	Emergent	Contrast
2	2, 5	9	2.1	An open, less controlling environment promotes creativity which leads to a range of unpredicted destinations.	Closed or highly structured environments tend to reduce creativity and produce work which is more staid and focussed on single, pre-known answers.
2	2, 5	9	2.2	Creativity involves risk-taking in terms of the lesson's desired outcomes and the degree of control offered to students.	A standard lesson with no risks or chances to deviate form the plan is less creative although may still be effective as a lesson.
2	2, 5	9	2.3	Creativity creates excitement both for student and teacher as the participants in a lesson stimulate each other.	Lack of creativity generates lessons that are acceptable but boring.
2	1 , 6	4	2.4	Too much support and easy solutions tend to reduce creativity. Change offers opportunities for creativity.	Lack of an easy solution or immediately relevant prior knowledge can stimulate creativity. No change makes it more difficult to encourage the effort needed to be creative.
2	8, 7	3	2.5	Operating a pre-defined, managerial role within a larger strategic plan can offer limited scope for creativity.	It is possible to adopt a creative role, e.g. developing ideas, when an individual can take responsibility for their own work.
2	1, 5	9	2.6	Active students who take ownership of their learning are more likely to be creative and creative students are more likely to own their learning.	Directed students are less creative and can find the direction offered boring.
2	1, 5	9	2.7	Defining and owning a problem rather than being given a simple problem to solve is more creative.	Telling students to respond to a pre-built, immediately soluble problem does not support creativity.
2	3, 4	8	2.9	Collaboration improves my creativity and the creativity of others in the team.	Working alone reduces creativity and make the ideas less resilient.
3	1, 6	5	3.1	The teacher as expert, delivering content defined by examination boards in a manner that closely links to requirements of the assessment vehicle. The student, and teacher, is passive.	The teacher as a coach or facilitator supporting students as they explore areas in a more open-ended manner is more creative
3	1,6	5	3.2	Students produce acceptable levels of work with limited 'deep understanding' revealed by problems that occur when students stray outside their comfort zones.	Work produced is of high quality, potentially university-level research stimulated by students' ownership of the material and process.
3	2, 4	8	3.3	The creative teacher as a risk-taker, formulating their own plans, exploring new topics and 'collaborating' with students whilst giving the material their own 'personal slant'. A sense of aiming high with high stakes for teacher and students.	Teacher operating to someone else's plans and with a sense of survival rather than success, not always knowing exactly what to do or how to perform to the standards they wish to experience.

T	P	D	CNo.	Emergent	Contrast
3	2, 4	8	3.4	Working within a comfort zone consisting of established content knowledge and possessing good key teaching skills which believe improve student learning.	Working outside normal area of expertise with unfamiliar content and novel teaching techniques that require skills the teacher does not have or believes are ineffective.
3	7, 9	3	3.5	Systems imposed from outside, often for other purposes, tend to reduce the room to develop appropriate solutions internally.	Agreed systems to support the efficient running and creative development of the department.
3	7, 5	4	3.6	Creativity involves degree of license. This needs to be tamed to make it socially acceptable and productive or it runs the risk of leading to obsessive, damaged or even dangerous personalities. The desire, and aptitude, for creativity does not override the rights of the rest of the group.	Creativity can be a force for good - but only when it is channelled into socially and personally productive paths. This implies a sense of control rather than license.
3	1, 8	6	3.7	Creative solutions recognise and abide by a set of rules for the benefit of the whole system and all people affected by it. Creativity is acceptable in some areas, e.g. ‘fun’ but might be questionable in other areas, e.g. rules for a game.	Slavish acceptance of system rules can limit creativity - sometimes in negative ways as the rules are not sufficiently flexible or sophisticated to take account of all circumstances.
4	6, 8	2	4.1	A detailed procedure can reduce creativity. The teacher is reduced to a deliverer of an experience, designed by others, rather than being the creator of it.	A more open situation requires the teacher to be more active in constructing the experience offered to the students.
4	2, 9	7	4.2	Most creativity exists at the start of a process when more options are possible. This is about inspired planning.	The latter stages of a process are closed down by the decisions made earlier and occasionally external forces. This is about a competent performance.
4	1, 6	5	4.3	Excessive control limits creativity. This control can reside in imposed rules or be self-imposed by adherence to larger goals (e.g. I need to do this to get my exam pass).	More personal control and options promote creativity.
4	1, 6	5	4.4	Novelty, surprise and fun (for students and teacher) are characteristics of a more creative lesson.	More of the same and a level of boredom are characteristics of a less creative lesson.
4	1, 2	3	4.5	Sharing ideas with others or developing ideas from others to give them your own ‘flavour’ is creative. Meetings that spark off these discussions and thoughts support creativity.	Activities devoted to passing on information or being told what to do, do not tend to encourage creativity.

T	P	D	CNo.	Emergent	Contrast
4	1, 8	4	4.6	It is easier to feel comfortable, and be 'in control' in a situation when you are familiar with it or have detailed instructions. This can lead to greater creativity.	Being outside your comfort zone can inhibit your willingness to take opportunities to be creative. The completion of the task can override your desire to be creative, expressed at other times, forcing you to opt for a safe, if simple, treatment.
4	6, 9	2	4.7	More detailed, more frequent controls are perceived as more restrictive and less likely to support creativity.	Targets in themselves do not have to reduce creativity if there is sufficient room to manoeuvre in how the targets can be approached.
5	4, 5	9	5.1	Developing new, exciting and improved activities - an emphasis on the potential for change and improvement.	Reporting on existing practice, often in a highly structured format requiring some 'housekeeping' work.
5	1, 6	5	5.2	Detailed instructions and procedures reduce creativity and demote activities to merely functional or mechanical. This is a job.	Options allows creativity to flourish bringing with it greater variety and quality of output and, potentially, enthusiasms where the student does much more than is required (or possibly wise). This is a joy.
5	3, 7	9	5.3	Chances to change the procedures and processes in a task while living within the overall purpose. Engaging with the task, and with others doing it, changes both the person doing the task and the components of the task itself.	The processes and procedures cannot be changed reducing the operator to a mechanical component rather than a creative, thinking contributor.
5	3, 7	9	5.4	Working with others can bring in perceptions and suggestions from others which will improve all. Science Department meetings, at their best, support this.	Working in isolation to solve an individual problem reduces creativity and personal development by locking out perceptions from others.
5	1, 8	2	5.5	Obeying the rules and fitting in can be justified in certain circumstances (e.g. if a teacher is outside their area of specialism) but will tend to restrict creativity.	To be creative teachers need to feel in control both of the students' learning pathways and the details of the content and skills to be covered.
5	1, 8	2	5.6	Creativity can be tempered in certain circumstances and this is appropriate and helpful.	Creativity can be problematic to a teacher when someone interferes with their plans, even if creatively, and changes things.
5	4, 5	8	5.7	Interesting, often novel and personally significant offering valuable opportunities for development.	Formal, functional and often justified by external forces. Simple a job to be done as efficiently as possible.
6	2, 9	3	6.1	Given time, creativity can produce interesting, exciting and engaging activities. When I have the power to choose I choose creativity.	Creativity can often be pushed out by other, more managerial and pedestrian, tasks or by simple lack of time.

T	P	D	CNo.	Emergent	Contrast
6	4, 5	8	6.2	Being creative is the default position when planning lessons, there is a constant bias towards producing something that has interest, engagement and excitement for students. This requires time and skill.	When time is unavailable or when working in an area of relative ignorance creativity is reduced and survival becomes the key driver.
6	4, 5	8	6.3	When I want to be creative I will be. It is a choice I make.	Sometimes I do not feel the need to be creative. I may want to do something else instead.
6	1, 7	6	6.4	Creativity involves room to change things and invent new ways to do things - that are often more interesting and exciting.	Highly structured procedures reduce the space for creativity - and can be boring for the teacher as well as the students.
6	1, 7	6	6.5	I like to be creative and recognise my own creativity in terms of 'arty' work (diagrams, drawings) and a willingness to invent new ways to do things.	Where there is no invention there is little creativity.
7	2, 1	6	8.1	Creative activities tend to be interesting and offer a variety of possible ways forward. These generally require more time and effort than non-creative approaches.	Non-creative activities offer very limited or no options in terms of the processes required to complete them or the nature of the final outcome. They can be easier to operate than creative activities.
7	5,7	3	8.2	A variety of novel options and products produced with many of them exhibiting the characteristics of good work - often surprisingly good.	A limited number of pre-existing solutions reviewed and a choice made that often appears to be driven by factors of compliance rather than excellence.
7	5,8	3	8.3	Creative activity can be less efficient in covering pre-prescribed content but offer deeper involvement with the material and potentially deeper understanding.	Creative approaches are probably not necessary or appropriate where transmission of a simple set of content in a given time is the key driver.
7	1, 8	4	8.4	It is difficult to engage with lesson plans or resources produced by other people because their thought processes may be different and there is a preference to do it in my own way.	Creative work generates level of engagement which reflects the commitment involved in engaging in it. The output reflects an aspect of the creator.
7	1, 9	2	8.5	Creativity involves taking risks and in some instances the possibility of 'failure' means the risk is not taken.	Tried and trusted is not seen as creative - but is safe.
7	2, 5	9	8.6	Creativity produces material that is personal, potentially idiosyncratic, and unexpected. There is a sense of students going beyond the task set.	Where a process is heavily structured and scaffolded creativity is reduced and the final product is not as rich as the alternative, more open tasks.

5.5 Reflection

The analysis of something as complex and iterative as a conversation is not always straightforward. The dangers of finding what you are looking for rather than what is there is always present to some extent and any analysis is, arguably, an interpretation rather than an objective description (Kyale, 2011). However, the process of creating the analysis and agreeing the constructs was carefully managed and involved transcription (done by the researcher) of over 10 hours of audio recordings, a review of notes taken at the time and, ultimately, validation by the teacher participants in a second open conversation where the sole purpose of the meeting was to modify, if required, and agree the construct wording. This gives me confidence that the constructs are valid descriptions of the teachers' thinking. Also encouraging was the degree of overlap between the participants' constructs. While some constructs were unique most were shared across participants implying that they did provide a view of a shared understanding rather than simply a record of seven teachers with completely idiosyncratic perceptions. This implied, to me, that a description of a shared understanding of creativity amongst science teachers was possible and so an answer to the original research question was available. Until this point it was possible that Kelly's 'constructive alternativism' (Kelly 1955) might mean that every single teacher had an entirely personal and unique understanding of creativity (mediated by their personal constructs) and that any generalisations from them would be trivial or couched in such generic terms as to be unhelpful.

These constructs are discussed further in Chapter 6 where they are categorised into a number of superordinate groups and a model to explore the roles of these constructs in lesson construction and review will be introduced.

Chapter 6: Discussion

6.1 Introduction

Chapter 5 described how 46 constructs were elicited from nearly 10 hours of transcribed conversations and provided a list of those constructs. Chapter 6 groups these constructs into six categories based on the focus of convenience (see Section 3.3.3.5) of the construct and evidence from the original teacher conversations. The six categories are discussed individually showing their contribution to the teachers' concept of creativity and reinterpreted as 'shared constructs'.

The chapter then goes further and classifies the categories to produce three superordinate groups, Enablers, Modifiers and Validators (EMV), describing these in terms of the role they play in the construal of creativity in science lessons by science teachers. The relationships between the three roles is explored and a model produced which is used make tentative predictions concerning the effect on lessons of sub-optimal operation of each role. These predictions are then checked against data from the original teacher conversations to see if there is a *prima facie* case to suggest that the model is valid and that further exploration would be valuable.

The chapter then discussies the limitations of the study and suggests for further work.

6.2 Constructs to categories

6.2.1 Creating categories

Each construct was placed in a single category based on the central issue it seemed to address. This was an iterative, inductive process involving constant comparison (Thornberg, 2012) between the emerging categories and the constructs until a satisfactory classification was available. The categories grew out of the constructs rather than being provided in advance or developed from the relevant literature about creativity. The reason for choosing an inductive approach was to allow the collected teachers' insights to appear in the final analysis rather than classifying their contributions into pre-existing groups. While a characteristic of Grounded Theory (Glaser and Strauss, 1967; Charmaz, 2006), this approach is also suitable for use in a Personal Construct Theory methodology (Kelly, 1955) with its insistence on the personal nature of understanding.

The sorting was done independently on two occasions, separated by roughly four months, and then a final classification was created by comparing the two versions and checking with the original transcripts. While the suggested categories changed somewhat during this process the wording of the constructs were left unchanged as they had been previously agreed by the teachers in the study. The eventual six categories were checked by a senior colleague to produce a final agreed classification. The categories are:

- Autonomy,
- Optionality.
- Collaboration

- Confidence
- Efficacy
- Excitement

These are explored in more detail in the coming sections.

6.2.2 Distribution of constructs

Table 6.1: Distribution of categories and constructs across teachers shows the distribution of constructs between the six categories and each of the teachers. The distribution across the teachers was fairly evenly spread with no category represented by a single teacher. Even collaboration, a category with significantly fewer constructs than the others, contained constructs from four separate teachers implying that it was not simply the concern of a single, rogue participant. Overall, the categories reflected constructs that were broadly held across the full range of teachers involved in the study.

Table 6.1: Distribution of categories and constructs across teachers

Category	Total constructs produced	Constructs by teacher in each category						
		T1	T2	T3	T4	T5	T6	T7
Autonomy	8		4		1		1	2
Collaboration	4	1	1		1	1		
Confidence	11	2	1	2	1	1	3	1
Efficacy	7	1		4		1		1
Excitement	8	1	1	1	1	2		2
Optionality	8	1	1		3	2	1	
Totals	46	6	8	7	7	7	5	6

The sections that follow explore these categories in more detail . Each construct is also identified by a Construct Number (Co. No.) as used in the full listing in Chapter 5. In a Co. No. the first digit refers to the teacher and the second to the order in which the construct was elicited. So a Co. No. of 4.5 means that it comes from Teacher 4 and was the fifth construct elicited during the conversation.

The quotes in the sections below that support the discussion are coded by teacher/page/line. So a coding of T1/p6/24 means the quote can be found in the transcript for Teacher 1 on page 6 at line 24.

6.3 Autonomy

6.3.1 Constructs in autonomy category

Co. No.	Emergent	Contrast
2.4	Too much support and easy solutions tend to reduce creativity. Change offers opportunities for creativity.	Lack of an easy solution or immediately relevant prior knowledge can stimulate creativity. No change makes it more difficult to encourage the effort needed to be creative.
2.5	Operating a pre-defined, managerial role within a larger strategic plan can offer limited scope for creativity.	It is possible to adopt a creative role, e.g. developing ideas, when an individual can take responsibility for their own work.
2.6	Active students who take ownership of their learning are more likely to be creative and creative students are more likely to own their learning.	Directed students are less creative and can find the direction offered boring.
2.7	Defining and owning a problem rather than being given a simple problem to solve is more creative.	Telling students to respond to a pre-built, immediately soluble problem does not support creativity.
4.2	Most creativity exists at the start of a process when more options are possible. This is about inspired planning.	The latter stages of a process are closed down by the decisions made earlier and occasionally external forces. This is about a competent performance.
6.1	Given time, creativity can produce interesting, exciting and engaging activities. When I have the power to choose I choose creativity.	Creativity can often be pushed out by other, more managerial and pedestrian, tasks or by simple lack of time.
7.4	It is difficult to engage with lesson plans or resources produced by other people because their thought processes may be different and there is a preference to do it in my own way.	Creative work generates level of engagement which reflects the commitment involved in engaging in it. The output reflects an aspect of the creator.
7.6	Creativity produces material that is personal, potentially idiosyncratic, and unexpected. There is a sense of students going beyond the task set.	Where a process is heavily structured and scaffolded creativity is reduced and the final product is not as rich as the alternative, more open tasks.

6.3.2 Autonomy and creativity

Autonomy appeared in constructs from four teachers (T2, T4, T6 and T7) and had two aspects. The first revolved around a sense of being able to initiate and direct projects while the second was concerned with the feeling that the project itself reflected something very personal about the relevant teacher - a sense of recognisable, personal ownership of the experience as opposed to interpreting others' plans. This dual nature reflects autonomy as described in Bujacz *et a*l (2016) as 'Autonomy refers to an experience of *ownership* and *volition* of one's behaviour' (my emphasis). While both aspects of autonomy appeared to be present in all four teachers the balance between the two aspects varied slightly.

Teacher 2 viewed autonomy most clearly in terms of his ability to choose his own role as an developer of new approaches. Autonomy to him meant the ability to make decisions and follow them through.

> ‘Some of the time I’m involved in developing things for the science department things like the Twitters things like the YouTube and, it’s getting teachers excited about new activities and it’s … or there’ll be consultations inside the science department where we discuss an idea and we try and develop an idea. So those sort of meetings are creative …’ (T2/p5/22)

Teacher 6 had a similar perception but from a more negative perspective: if she had autonomy she would be able to make choices and so be more creative but this autonomy was often curtailed by tasks prescribed by the school management (which, to her, meant the after-school science department meeting). Compare her comments about preparing for her own class (where she felt she had autonomy) with her thoughts about the after school departmental meeting (where she felt she had limited control).

> ‘Ok, so this one <card 2: Planning a lesson for my favourite class> you're obviously going to try and make it interesting … you're going to try and be creative and put lots of differentiation activities in it … you're gonna try and engage the pupils…’ (T6/p2/5)

The science department meeting was perceived as being much more directed.

> T6 Yeah, it’s very <directive> ! And you always have an agenda… what you've got to do … and there is AOB at the end but by the time you've got through the rest of the agenda you're getting to AOB and thinking “I’ve got to get home now” or “I need to go and pick up so-and-so and so-and-so” , “Got to get to the gym” or “Got to get to you know …” and … we don't always have time to be creative unfortunately which is very sad. (T6/p3/14)

Teacher 4 also spoke of ‘autonomy as control’ when he explained that most freedom exists at the start of a project - as it progressed the ability to control was reduced as the day-to-day reality of teaching took over.

The other aspect, ‘autonomy as reflective of a personal preference’ was described by Teacher 7 who talked of the need for his lessons to be personal and reflect his personality. He complained that he could not use lesson plans supplied by others as they did not have his personal involvement.

> ‘But it’s very rare that I’ll just be able to teach that lesson as it’s been handed to me or I’ll be able to use that resource as it’s been handed to me. Nearly always it will involve tweaking or making it so it fits to whoever’s gonna be in front of me really I suppose rather than actually it fits to me… or so that it works in terms of my thought processes …’ (T7/p4/33)

The teachers who contributed to this category seemed to regard autonomy as a power that allowed them to exercise control and suggest activities based on personal preferences and understanding. This dual sense of being about me, my power and personality, is a significant part of the teachers’ perception of creativity.

The autonomy category shares this 'opportunity to make decisions' with the category called Optionality (see Section 6.8) although in Optionality the sense is more of options within an activity that might have been generated by others. In the autonomy category the sense of 'reflecting me and my personality' is clearer.

The comments above concern teacher autonomy. When issues of student autonomy came up in conversations teachers generally expressed pleasure and praised students 'taking ownership' (T2/p6/24) of their own learning. Teacher 2 raised the idea of autonomy for students when he spoke of of an approach he uses with revision lessons. He runs his own YouTube channel and students can access this to see lessons, explanations and so on prior to attending formal revision lessons - effectively a 'flipped classroom' approach (Ozdamli and Asiksoy, 2016). Students can then use the content on the channel to create their own revision documents and plans. The teacher felt that he had not just given control to them but positively encouraged them to develop something that reflected their personality and preferences.

> 'And from what I've done with that <the YouTube and flipped classroom approach> … there has been so much creativity, so much sort of taking ownership of their revision because they're doing their own thing … I'm not giving them any guidance with it. I'm just giving them the tool and the way they use that tool is totally up to them. (T2/p6/24)

However, when talking about the risks of creative lessons many of the teachers clearly identified student behaviour and choice as an issue. In this instance there was a desire to control students rather than allow them autonomy. Teacher 3 particularly spoke of his worries of unbridled creativity amongst students and the disruption it could cause (see section 5.3.3.4 for further discussion).

> 'Then the whole process actually becomes much more creative to the point where perhaps where it can become too creative because you keep going round in … almost a spiral going up the staircase and you never actually quite reach the top because there's always a bit further that you can go uh…(T3/p11/5)

> '… and so I don't like to stifle creativity I'd love to be able to say to my students 'Be as creative as you want, go away the world is your oyster' but ultimately as well if you keep on that creative process and keep on and keep on … how are they gonna pay for it? How are they going to develop those other skills they need to be competent reasonable adults in a reasonable society.' (T3/p12/12)

The majority of teachers in this study regarded autonomy as an essential prerequisite for creative work and a number complained that their lack of control over their own lessons (due to curriculum content, examination pressures or even departmental marking guidelines) inhibited their ability to be creative. All of the teachers involved, when asked if they were creative, insisted that they were and could certainly quote examples of work they had done which appeared novel. This implies that where they felt they were not creative, and they themselves claimed to be not creative, this was due to some external circumstance and not an internal lack of capability.

As well as providing the chance to make decisions and initiate activities autonomy was also seen as as aspect of personality - the 'permission' to behave as themselves. So, the control autonomy

offered was used not just to initiate projects but also to behave in a way that the teachers felt reflected their personalities and values.

The significance of autonomy and optionality in teachers' understanding of creativity is perhaps not surprising. Autonomy is seen as an essential component of an environment conducive to creativity (Amabile,1989, 1996; Dombrowski *et al*, 2007; Sternberg and Williams, 2003) while an assault on teacher autonomy in the shape of greater centralised control of curriculum and pedagogy through assessment systems, Berliner's 'curriculum narrowing' (Berliner, 2011), has been deployed as a reason for what Kyung Hee Kim (Kyung Hee Kim, 2011) calls the 'creativity crisis' - the fall in creative ability amongst American school children as they progress through the school system. in the UK similar concerns about lack of teacher autonomy have been voiced by researchers (Compton, 2010), curriculum developers (NAACE, 1999) and, in this particular study, practicing teachers.

While the teachers in this study clearly associate autonomy with creativity in themselves some of them have concerns about affording the same autonomy to students. In this they echo findings in the literature that report that creative students can be more difficult to manage and can disrupt pre-prepared lesson plans. (Morais and Azevedo, 2011; Scott, 1999). This should not however be interpreted simply as teachers hoping for an easy lesson with a compliant class. In seeking control in their lessons teachers may well be merely passing on the pressure they themselves are under to deliver top grades in assessments or have orderly, well-managed classrooms that will not be criticised by visiting inspectors or school management.

6.4 Optionality

6.4.1 Constructs in optionality category

Co. No.	Emergent	Contrast
1.1	Creativity depends on, and generates, options and having a range of possible ways forward.	No freedom to deviate from provided plans makes creativity impossible and unnecessary or irrelevant.
2.1	An open, less controlling environment promotes creativity which leads to a range of unpredicted destinations.	Closed or highly structured environments tend to reduce creativity and produce work which is more staid and focussed on single, pre-known answers.
3.1	The teacher as expert, delivering content defined by examination boards in a manner that closely links to requirements of the assessment vehicle. The student, and teacher, is passive.	The teacher as a coach or facilitator supporting students as they explore areas in a more open-ended manner is more creative
4.1	A detailed procedure can reduce creativity. The teacher is reduced to a deliverer of an experience, designed by others, rather than being the creator of it.	A more open situation requires the teacher to be more active in constructing the experience offered to the students.

Co. No.	Emergent	Contrast
4.3	Excessive control limits creativity. This control can reside in imposed rules or be self-imposed by adherence to larger goals (e.g. I need to do this to get my exam pass).	More personal control and options promote creativity.
4.7	More detailed, more frequent controls are perceived as more restrictive and less likely to support creativity.	Targets in themselves do not have to reduce creativity if there is sufficient room to manoeuvre in how the targets can be approached.
5.2	Detailed instructions and procedures reduce creativity and demote activities to merely functional or mechanical. This is a job.	Options allows creativity to flourish bringing with it greater variety and quality of output and, potentially, enthusiasms where the student does much more than is required (or possibly wise). This is a joy.
5.3	Chances to change the procedures and processes in a task while living within the overall purpose. Engaging with the task, and with others doing it, changes both the person doing the task and the components of the task itself.	The processes and procedures cannot be changed reducing the operator to a mechanical component rather than a creative, thinking contributor.

6.4.2 Optionality and creativity

The term optionality is used to describe the chance to choose between a variety of approaches to tackle a problem and produce a range of possible solutions. It is distinguished in this context from autonomy in that autonomy is about power to choose to act, or not, at the start of a project while optionality is more concerned with the choices made during the project between different ways forward. Where optionality is high two different people may both seek to solve the same problem but tackle it in different ways, respond to unexpected events with different tactics and actions and end up with slightly different, equally valid, solutions to the initial problem posed. Constructs in this category were present in every teacher conversation and were unusual in that the conversations described the notion of options for students as well as teachers. In most of the other constructs the emphasis was firmly on the teacher rather than the student.

Teachers were clear that they live under pressure to complete certain tasks and reach certain targets and that these can reduce optionality and consequently creativity. This reduction of teaching to relentless series of inevitable events was explicitly criticised by one teacher even as he recognised the pressures that forced him to operate in this way.

> ‘It’s ultimately because of various factors and outside pressures this is ultimately what we are in the business of doing and our … essentially most of my teaching is preparing students for an examination, so … Lesson: assessment: intervention. Lesson: assessment: intervention. And it’s a continuous cycle …’ (T3/p1/14)

He continued that this type of teaching had its drawbacks as students could not respond creatively to unfamiliar problems.

> ‘The problem comes up obviously when they're exposed to an exam in a context that they're perhaps not sure about or they’ve not seen these questions before … or the

example they've got, so for example an adaptation of a …of some sort of extremophile to an environment is is not an example they've come across before and they go out of their comfort zone and … yeah… spanners come flying out of the box.' (T3/p1/21)

The teacher claimed that this programmed approach did not encourage creativity. The lack of optionality for students prevented creativity in them even as the over-prescriptive Schemes of Work prevented the teacher from being creative.

The link between the presence of optionality and the presence of creativity was also mentioned by Teacher 1.

GP From your point of view, is creativity linked with having many possible ways of doing it?

T1 Yeah! Because you can be creative in many ways and you can plan for creativity in many ways …

GP And you can't creatively mark because…?

T1 'Cause it's to a mark scheme. If it's an assessment, a public exam they all have to be marked the same, consistently. (T1/p2/6)

This was also mentioned by other teachers including Teacher 4.

'Because you've got a sort of free rein with that <2: Planning a lesson for my favourite class>, it's creative and you can do essentially whatever you like um with that … with these two … with the marking an assessment and covering a supply lesson generally you're limited on doing what you've got to do … marking, to do it, follow the mark scheme there's no being creative about it.' (T4/p2/18)

Optionality is concerned with process and output. Creative lessons have high optionality in that the process the teacher and students engage in is open to modification throughout and the final output is not fixed beyond the need to meet certain broad success criteria (see the discussion about efficacy earlier). A lack of creativity is characterised by an algorithmic, fixed process with a tightly-specified output demanded, often, by parties outside the immediate learning system (e.g. awarding bodies, government curriculum demands). Teachers clearly felt optionality was crucial for creativity and that their degree of optionality was somewhat limited. They also accepted that they reduce the optionality available to students at times and justify this in terms of external demands (time, curriculum coverage, examination pressures) which they have limited or no control over.

The distinction between autonomy, the freedom to choose to engage in a topic or problem because it reflects in some way an interest or aspect of the participant, (Bujacz *et al,* 2016) and optionality, the opportunity to change procedures during an activity in the light of experience, is subtle in practice. Optionality can look like exercising autonomy in every stage of a project. A teacher might autonomously choose to use this procedure or this measuring instrument in the light of the previous result. These 'small scale' choices are actually driven to some extent by

those previous experiences and few hold great personal significance and so are not recognisable as autonomy in Bujacz's sense. However, teachers see this optionality (the chance to respond appropriately to changing circumstances) as crucial for creativity. They see themselves as skilled operators with responsibility for managing a classroom and not simply automatons following a scheme created elsewhere. This resonates with other research about professional roles, such as a study of the management of nuclear power plants in Finland. In a study looking at how technicians viewed the rules supplied to operate the power plant Norros et al (Norros, Liinasuo and Savioja, 2014) found that those who slavishly followed the rules as prescribed (no optionality) generated more alarms and potential problems than those who operated as if the rules were slightly more like guidance and responded creatively and intelligently to the data in front of them in the plant control room (some optionality).

As with autonomy, teachers have mixed views on optionality. While they insist lack of optionality reduces their own creativity they are still willing to reduce student optionality in order to guide them towards the content they need to cover to complete the syllabus. This contradiction is not lost on the teachers in this study.

6.5 Collaboration

6.5.1 Constructs in collaboration category

Co. No.	Emergent	Contrast
1.4	Creativity benefits from collaboration with multiple inputs from many people.	Individual creativity is more limited than collaborative creativity.
2.9	Collaboration improves my creativity and the creativity of others in the team.	Working alone reduces creativity and make the ideas less resilient.
4.5	Sharing ideas with others or developing ideas from others to give them your own 'flavour' is creative. Meetings that spark off these discussions and thoughts support creativity.	Activities devoted to passing on information or being told what to do, do not tend to encourage creativity.
5.4	Working with others can bring in perceptions and suggestions from others which will improve all. Science Department meetings, at their best, support this.	Working in isolation to solve an individual problem reduces creativity and personal development by locking out perceptions from others.

6.5.2 Collaboration and creativity

Collaboration was mentioned by four teachers (T1, T2, T4 and T5) who all regarded it in a positive light. Teacher 1 had the most positive view describing after school meetings at her school with obvious approval.

T1 OK. I've put these two together …um… Facilitating student-centred projects and Attending science department meeting because … you can do that as a group of

teachers and creativity will be coming from more than one person and you plan together whereas teaching a revision lesson … really that's just coming from you. I mean you can jointly plan but usually when its your own class you'll do that in your own time personally for your students in your class.

GP OK, so in terms of creativity … creativity works best as a collaborative effort?

T1 Hmmm … I think yes to a certain extent because you can bounce ideas off each other and see if people have used ideas before or used resources before and then you may come up with something new there and then. So bouncing things off each other other works really well not only within departments but across the school as well. I think it's nice to have inputs from everywhere … cause if you come up with something yourself for your own classes I think most of the time you go away and share that anyway … so.. you know… Oh, I've tried this and it works really well… (T1/p5/13)

Similarly Teacher 2 (who worked at the same school) saw collaboration as a key part of creativity.

'Creativity for me is not just me creating something, it's working within the team to come up with ideas about things that I would never even think about … helps me develop my ideas.' (T2/p8/33)

However, Teacher 2 was slightly more even handed about after-school meetings than Teacher 1 saying

'It <the meeting> can be creative and it can be non-creative.' (T2/p5/20)

It was non-creative when it involved the passive receipt of information.

' … some information is being given to us… and it's very much no creation at all, you just sit there and you just listen to the information.' (T2/p5/29)

The 'can be creative and it can be non-creative' remark from Teacher 2 above revealed worries about after school meetings shared by other teachers. Teacher 4 explained that an after-school science department meeting was not an example of collaboration because most of the people attending were present only to report progress, receive instructions or information rather than to engage in creative work.

'I feel the meetings here are very much …uh… where's this? Where's this? Where's this? What intervention are you putting in place to do that? What are we doing for this? What are we doing for this? And that's… its more of an admin-y type time as opposed to a let's share our ideas type time.' (T4/p7/20).

So, while collaboration inevitably involved some loss of autonomy the teachers who mentioned it clearly valued collaboration where all had an equal voice and there was some sense of 'mutuality' (Bevins and Price, 2014). However, they were quick to point out that when 'collaboration' was merely being instructed, or informed, they were not happy to give up their autonomy.

Teacher 5 recognised that collaboration was useful but that this collaboration should not produce uniformity.

> ‘Um…. we…. uh…. as a department do some communal ones <student centred projects>… so there’s one on the wall here which is a … a project to research an animal. So the students … we all do it rather than me just come up with my own science project. So within the constraints of a departmental policy… a departmental project … there’s freedom to roam around with that but ultimately you're still doing the same kind of things … um…. hopefully …. and again it is …it is … centred towards possibly preparing them for these things <public examinations>. Why do we do them? Not just completely abstractly we’re doing them based on a curriculum or on a syllabus but they are, yeah, there is that freedom to be … to be different, you know, … to do something else.’ (T5/p4/13)

There was also some potential conflict between autonomy and collaboration. If autonomy involves ‘my control’, ‘my power’ and ‘my personality’ (see Section 6.3) then collaboration could be seen to dilute this in favour of ‘shared control’, ‘our power’, a ‘shared and approved personality’ and so on. While Teacher 7 was alone in explicitly saying he would not be able to use resources and lesson plans produced by other teachers, others seemed to have similar opinions, if perhaps to a lesser degree.

> ‘But it’s very rare that I’ll just be able to teach that lesson as it’s been handed to me or I’ll be able to use that resource as it’s been handed to me. Nearly always it will involve tweaking or making it so it fits to whoever’s gonna be in front of me really I suppose rather than actually it fits to me… or so that it works in terms of my thought processes …’ (T7/p4/33)

Despite these worries there were seen to be benefits to collaboration and sharing of workload. All of the teachers this study had access to departmentally-produced Schemes of Work, resources produced in-house by other teachers and a range of commercially-produced resources (paper-based and digital). All of them appeared to use them to some extent.

It was also noticeable that two of the teachers spoke more highly of departmental meetings than the remaining five. They saw them as an opportunity to discuss issues and collaborate. Both of these teachers were Heads of Science in their respective schools. The other teachers from those schools had a much more negative view of the same meetings.

Collaboration was an important part of the teachers’ understanding of creativity. They seemed to value working with colleagues on shared projects and enjoyed giving and receiving inputs on projects. There was also a clear assumption that products of creative activities are improved by collaborative working. However, collaboration had to exhibit mutuality and a sharing of power (Bevins and Price, 2014) rather than being simply a group of people (e.g. a Science department) working together under the control of someone else (e.g. a Head of Science or Vice-Principal with responsibility for curriculum). Furthermore, collaboration could produce a product that could, in turn, be modified to match the particular approaches of teachers as well as the specific needs of their students. Collaboration was not seen as a way to produce compliance or uniformity but as an opportunity to generate a wider range of higher quality ideas and approaches.

This matches perceptions in the literature where an open, collaborative environment and a no-blame culture are seen as critical for creativity to flourish (Amabile, 1989, 1996; Dombrowski et al, 2007; Sternberg and Williams, 2003). Within this study the ethos of the school was clearly important as it either helped to foster collaboration through open and inclusive management structures (e.g. science department meetings that looked at developing ideas rather than simply receiving instructions) or generated top-down management directives (e.g. the detailed rules concerning marking and student feedback). The idea that group creativity is enhanced by 'mutuality' (Bevins and Price, 2014) is unsurprising and, again, appears in a number of suggestions from creativity researchers and curriculum developers for ways to improve creativity of students in the classroom. Some researchers are suggesting that online systems, with hierarchies reduced somewhat by equal posting rights for all contributors, can help to build collaborative creativity. (Bettonia, Bernharda and Bittel, 2015). However, none of the teachers in this study mentioned online environments as collaborative areas although a number used them for sharing resources. This further emphasises that 'collaboration', as used by the teachers in this study, is more about mutuality, shared decision-making and development and less about sharing workload.

In summary, confidence to take risks is a key feature of creativity and collaborative environments can support teacher confidence. However, collaboration must be authentic, in the sense that mutuality is assured and power is devolved, or 'collaboratively-developed' strategies (e.g. approaches to marking) enforced on all teachers can become controlling factors and reduce optionality and so creativity.

6.6 Confidence

6.6.1 Constructs in confidence category

Co. No.	Emergent	Contrast
1.2	Risks are an essential part of creativity - to explore new approaches. These risks can be managed by careful planning and personal performance and flexibility during the lesson.	External direction can make the risks beyond the teachers control which tends to reinforce safe behaviour.
1.3	There are a number of simple techniques that can inject creativity into a science lesson at any time.	Planning lessons can encourage creativity in students by building in appropriate activities.
2.2	Creativity involves risk-taking in terms of the lesson's desired outcomes and the degree of control offered to students.	A standard lesson with no risks or chances to deviate form the plan is less creative although may still be effective as a lesson.

Co. No.	Emergent	Contrast
3.3	The creative teacher as a risk-taker, formulating their own plans, exploring new topics and 'collaborating' with students whilst giving the material their own 'personal slant'. A sense of aiming high with high stakes for teacher and students.	Teacher operating to someone else's plans and with a sense of survival rather than success, not always knowing exactly what to do or how to perform to the standards they wish to experience.
3.4	Working within a 'comfort zone' consisting of established content knowledge and mastery of personally valued teaching skills supports creativity.	Working outside the teacher's normal area of expertise with unfamiliar content and / or teaching techniques that require underdeveloped skills or are viewed as ineffective reduces creativity.
4.6	It is easier to feel comfortable, and be 'in control' in a situation when you are familiar with it or have detailed instructions. This can lead to greater creativity.	Being outside your comfort zone can inhibit your willingness to take opportunities to be creative. The completion of the task can override your desire to be creative, expressed at other times, forcing you to opt for a safe, if simple, treatment.
5.5	Obeying the rules and fitting in can be justified in certain circumstances (e.g. if a teacher is outside their area of specialism) but will tend to restrict creativity.	To be creative teachers need to feel in control both of the students' learning pathways and the details of the content and skills to be covered.
6.2	Being creative is the default position when planning lessons, there is a constant bias towards producing something that has interest, engagement and excitement for students. This requires time and skill.	When time is unavailable or when working in an area of relative ignorance creativity is reduced and survival becomes the key driver.
6.3	When I want to be creative I will be. It is a choice I make.	Sometimes I do not feel the need to be creative. I may want to do something else instead.
6.5	I like to be creative and recognise my own creativity in terms of 'arty' work (diagrams, drawings) and a willingness to invent new ways to do things.	Where there is no invention there is little creativity.
7.5	Creativity involves taking risks and in some instances the possibility of 'failure' means the risk is not taken.	Tried and trusted is not seen as creative - but is safe.

6.6.2 Confidence and creativity

All seven of the teachers mentioned confidence as a key component of creativity. This was because, as they explained, creativity was a risky business and being willing to take those risks required a degree of confidence. For example, allowing students to work in different ways or make some choices about their studies was seen as a risk by teachers. Their willingness to embrace this risk (and so engage in behaviour the teachers would recognise as creative) depended on their confidence mediated by these factors listed below.

- Knowledge of the students: they were more likely to take risks with familiar classes where they had a good relationship with students rather than unknown or difficult classes.

- Subject area: teachers were happier to be creative when they had the background knowledge and were working within their specialism.
- Assessment pressures: examination preparation classes were considered too valuable for the students to allow more unusual or risky activities.
- OFSTED inspections: these were perceived as high-risk for the teacher with strong pressure to conform to a pre-set notion of an effective lesson.

The quotes below are typical of the comments about risks and which classes the teacher could take risks with - and where they would play safe.

> 'If you're planning your own lesson for your own class you can actually plan more I think… you can take more risks.' (T1/p4/15)

> 'So… yeah… so… for example an A-level topic that … um… I'm not familiar with, that I'm … is outside of what I can … or outside of what I can do at degree level I'm going to have to do the research and the lesson is probably going to be quite simplistic and quite teacher-led of me going 'this is what you need to know, this is …um…' (T4/p9/35)

> 'I've done three or four OFSTED inspections … now maybe five, I'm trying to remember. All of them have been … uh… not entirely functional but more functional … um … preparing evidence of things which is there … just collating evidence, maybe documenting things that in a specific form that you already have in a different form … um… and making sure everything in order essentially. Doing a bit of housekeeping. Doing a bit of tidying up. Preparing for an OFSTED inspection rather than creating… being creative … doing something new and exciting for a for a class…' (T5/p2/20)

Despite this wariness about taking risks the teachers recognised that creativity required a willingness to take risks. Teacher 1 was even clearer saying he took risks 'a lot'.

> 'Yeah, I do that < take risks> a lot because if you're planning something creative or something … that to me is talking a risk that the learners have never done before. And so how are they going to take that? Are they going to learn from it or not? Or are they going to behave well in the classroom doing that or are they going to be able to learn from each other if you've planned group tasks. It's… you have to take a risk to be creative in my opinion.' (T1/p2/12)

Teachers equate the confidence to take risks with a number of factors but none mentioned their seniority within the department or gave any sense of the power that this might confer. It is easy to suggest that teachers higher in the hierarchy (Heads of Science) with more experience and greater notional power might be able to take more risks than those at lower levels in the department. However, senior members of staff may feel more limited by performance issues in the shape of student examination results and younger staff might be more willing to take risks. Indeed T1 specifically mentions this willingness to take risks as a newly-qualified teacher:

> 'I think they're <newly qualified teachers or student teachers> naive … not the word … I remember being a student teacher and I thought I could rule the world…I thought I can try this, I can try this and I wasn't afraid of taking risks and I'd try anything

because I knew if it failed nobody would hold me to account because it was only my first year teaching and I want to try everything to see what works so I can get better.' (T1/p9/10)

When faced with a supply class, or teaching outside their specialism, the teachers' confidence was reduced and they took fewer, if any, risks. The teachers maintained that this meant that they were less likely to be creative. Confidence was thus seen as essential in creativity - possibly because it affected the number of risks the teacher is prepared to take.

However, some teachers claimed they responded well to the pressure when faced with novel or unexpected situations, e.g.covering a supply lesson.

GP Where do you feel you would be more naturally creative?

T1 I think it would have to be in terms of this one, the cover lesson, because its outside of your specialism… well, it may be if it's not a science covering… um and uh… you may not have come across the students before so you may have to adapt things very quickly. (T1/p4/32)

In this instance, the pressure to manage the classroom and deliver a good lesson could stimulate a creative response in the teacher. However, this option for the teacher to be creative did depend on good behaviour and a level of ability in the students, as Teacher 6 explained.

T6 I would say your creativity depends upon what the pupils are like. If they are a bunch of … like … kids who are not quite focussed you can't always be as creative with them you've got to be more 'on task' and more kind of rigid with your rules …

GP Because?

T6 Because elsewise they've got a potential to kind of go off task and … you know… if you give them free rein to do things they're not always going to do what you want them to do… won't always go the way you want <laughs>

GP Quite often <laughs>

T6 As we know! Yes! So I do think, yeah, you've got to be … certain classes. If they're good classes and they're quite bright and they're quite inspired you know they're … they want to learn … like little sponges you can do that <be creative> um… if they're not it's different… OK? (T6/p14/24)

Confidence was seen as essential if the teachers were to take a risk which they all claimed was a key part of creativity. Their confidence grew out of their familiarity with the subject or the teaching group, previous planning, good behaviour and high ability levels in their students.

The notion that creativity involved taking risks reflected the assumption that approaches that are 'tried and trusted' and predictable are, in some way, less creative. This may link with the notion of excitement (see Section 6.7) which teachers expected to feel, and observe in their students, when activities were creative.

Where autonomy and optionality are *required* for creativity, teacher confidence, and collaborative working environments that can support teacher confidence, act as *supporters* of creativity.

Creativity requires the taking of risks (Simmons, and Ren, 2009; Bramwell et al, 2011; Kaufmann and Sternberg, 2007) and creative teachers are routinely described as 'self-confident' and 'risk-takers' (Abdulla and Cramond, 2017). This argues for confidence, described by teachers here both in terms of subject knowledge and student familiarity, as a key aspect of creativity. There are many sources mentioned by teachers in this study for their confidence in their own ability: knowledge of the subject (formalised by possession of a university-level qualification), a degree of training (both initially and through continuing professional development), any teaching experience (older teachers in this study tended to be more comfortable in the classroom than a newly-qualified teacher) and, crucially, their professional environment (both their students and their teaching colleagues). This suggests that one way to support teachers' creativity is to boost their confidence - an idea discussed further in Section 7.6.2.

6.7 Efficacy

6.7.1 Constructs in efficacy category

Co. No.	Emergent	Contrast
1.6	Creative activities are matched to the needs of the audience and must be fit for purpose.	If creative activities are inappropriate (not matched to the needs of the audience) they will fail and the trust between teacher and student can be eroded.
3.5	Systems imposed from outside, often for other purposes, tend to reduce the room to develop appropriate solutions internally.	Agreed systems to support the efficient running and creative development of the department.
3.6	Creativity involves a degree of license. This needs to be tamed to make it socially acceptable and productive or it runs the risk of leading to obsessive, damaged or even dangerous personalities. The desire, and aptitude, for creativity does not override the rights of the rest of the group.	Creativity can be a force for good - but only when it is channelled into socially and personally productive paths. This implies a sense of control rather than license.
3.7	Creative solutions recognise and abide by a set of rules for the benefit of the whole system and all people affected by it. Creativity is acceptable in some areas, e.g. 'fun' but might be questionable in other areas, e.g. rules for a game.	Slavish acceptance of system rules can limit creativity - sometimes in negative ways as the rules are not sufficiently flexible or sophisticated to take account of all circumstances.
5.6	Creativity can be tempered in certain circumstances and this is appropriate and helpful.	Creativity can be problematic to a teacher when someone interferes with their plans, even if creatively, and changes things.
1.6	Creative activities are matched to the needs of the audience and must be fit for purpose.	If creative activities are inappropriate (not matched to the needs of the audience) they will fail and the trust between teacher and student can be eroded.

6.7.2 Efficacy and creativity

Efficacy is used here for the notion that a lesson has a particular job to do (support and validate students' learning) and that a lesson which exhibits efficacy should show measurable progress for students. Three teachers (T1, T3 and T5) mentioned efficacy with one, a Head of Science (T3), talking at length about it. This may have been due to the increased responsibility he felt for management of his department and because, if public examination results started to decline, he would be the first person that the Senior Management Team at the college would contact. He talked of teachers having to deliver for students and 'play by the rules' and that if some teachers did not do this there would be, potentially painful, repercussions

> 'Whilst I'd love us … as an adult to say to people you can be as creative as you wish to be, you know… I'm quite liberal in that respect, go out do what do what you want … but I … I … but if your creativity impinges on my … ability to do my job or if your creativity stifles my right to do something else I need to have words with you and say something …' (T3/p16/13)

However, he also talked of students doing excellent 'university level' work (see quote from T3/2/8 in Excitement section that follows) when they were engaged in project lessons which he recognised as open-ended and creative. Despite this, he was also concerned that open investigative work, although it was creative, did not always deliver the material the students needed to cover.

> 'I would class that < 5: Facilitating student-centred science projects> as facilitating or coaching … it's helping to bring along the young person actually rather than being very didactic and saying 'This is what you must do because, you know, the AQA or Cambridge or Edexcel say this is what you have to do.' (T3/p2/14)

In this instance creativity would not be effective for learning *as defined by the awarding bodies* (AQA, OCR and Edexcel) even if the students were learning valuable skills and concepts. Here he felt that complete licence could lead to students following their own paths which might be unwise or not relevant. This implied that he was willing to reduce their autonomy and impose some direction and control on them because he assumed a greater knowledge of the targets that they had to meet - even if he did not always approve of those targets.

As far as Teacher 3 was concerned, creative lessons where students engaged actively and were self-directed with good intrinsic motivation (Deci and Ryan, 2008) still had to be appropriate in terms of the level of demand and the content covered. This is true of all lessons to an extent and emphasises that a teacher is often faced with a dilemma about student autonomy. A teacher may feel it is appropriate to intervene to remove some of the students' autonomy and their right to make, sometimes unfortunate or counterproductive, choices in order to ensure the lesson remains appropriate in the terms listed above. To add complexity to this consideration, reducing student autonomy may not be significant in a revision lesson, where their options are limited and the content to be covered is tightly defined, but in an open-ended project, where creativity is at a premium, reducing autonomy could prevent the creativity the teacher is seeking in their students even as it prevents the students from making foolish decisions.

Teacher 1 saw efficacy as being tightly linked to the needs of the students and the teacher's ability to respond, in an unencumbered way, to those needs and give the students the idea that the lesson had been planned for them - the teacher was not simply following a pre-ordained approach that they had used with every other class. As the quote below emphasises, the teacher believed that efficacy was more than simply deploying a proven teaching technique without reference to the students or the teacher's relationship with them.

> 'Even though you watch, growing up as a teacher, different teachers, different styles , different ways of getting things across how teachers write their questions, how they ask their questions, get verbal feedback … but you still have deliver it with your personality and your … because I don't think the students will have that relationship with you if you don't. I think they know when you're false … um … and they know when you've not planned for them.' (T1/p7/32)

However, while planning for efficacy the teacher was aware of the risks involved. He took the risk and had a lesson that he regarded as highly effective (my emphasis):

> 'And I thought, you know, are they gonna behave while they do this? Are they going to be able to push themselves where they're creating questions and actually analysing what they've got to give the answer ? So I thought, no I wanna try it. So trust them. And actually *its one of the best lessons ever* and they've learnt so much from it that I got two lessons into one. So I think that that was a really creative lesson.' (T1p8/20)

Teachers expected creative lessons to be effective not just random explorations where students had fun. Some worried more than others about how tightly focussed on the curriculum demands a lesson might be when students were creative.

All definitions of creativity (see Section 2.2.3.2) include the notion of value as an indicator of creativity (Sternberg, 1999) and it is not surprising that teachers would regard a lesson which 'appeared' creative (perhaps through lots of unusual activity) but in which the students failed to learn anything as a waste of time or a chance to play - certainly not authentically creative. Novelty, by itself, is not enough to describe creativity and even in descriptions of mini-c (Kaufman and Beghetto, 2009), the very first stirrings of creativity in small children, the need for value is clear (see Section 2.2.3.3 The scale of creativity). What is surprising is that one of the arguments routinely deployed against more creative (i.e. open, less-structured) learning environments is that they do not work as well as controlled environments and 'direct instruction' (Stockard *et al*, 2018) yet the teachers in this study claim exactly the opposite that open, creative environments promote more, and higher quality, learning. The teachers' perceptions are more in line with suggestions from Csikszentmihalyi concerning 'flow' (Csikszentmihalyi, 1996) which is a state where creative workers lose track of time and work at levels potentially above their normal performance to generate exceptional work (in this study 'work' means students learning about science). The increased motivation from a degree of autonomy (a key component of creativity-friendly environments) predicted by self-determination theory (Deci and Ryan, 2008), is also claimed by the teachers in this study to improve performance (see Section 6.3.2).

6.8 Excitement

6.8.1 Constructs in excitement category

Co. No.	Emergent	Contrast
1.5	Exciting and off the wall ideas are the sign of creative teaching.	Rigid and boring with no excitement.
2.3	Creativity creates excitement both for student and teacher as the participants in a lesson stimulate each other.	Lack of creativity generates lessons that are acceptable but boring.
3.2	Students produce acceptable levels of work with limited 'deep understanding' revealed by problems that occur when students stray outside their comfort zones.	Work produced is of high quality, potentially university-level research stimulated by students' ownership of the material and process.
4.4	Novelty, surprise and fun (for students and teacher) are characteristics of a more creative lesson.	More of the same and a level of boredom are characteristics of a less creative lesson.
5.1	Developing new, exciting and improved activities - an emphasis on the potential for change and improvement.	Reporting on existing practice, often in a highly structured format requiring some 'housekeeping' work.
5.7	Interesting, often novel and personally significant offering valuable opportunities for development.	Formal, functional and often justified by external forces. Simple a job to be done as efficiently as possible.
7.1	Creative activities tend to be interesting and offer a variety of possible ways forward. These generally require more time and effort than non-creative approaches.	Non-creative activities offer very limited or no options in terms of the processes required to complete them or the nature of the final outcome. They can be easier to operate than creative activities.
7.3	Creative activity can be less efficient in covering pre-prescribed content but offer deeper involvement with the material and potentially deeper understanding.	Creative approaches are probably not necessary or appropriate where transmission of a simple set of content in a given time is the key driver.

6.8.2 Excitement and creativity

Six teachers (T1, T2, T3, T4, T5, T7) claimed that excitement and enjoyment was a characteristic of lessons that they regarded as creative. They described excitement as a sense of engaging in something that is enjoyable, sometimes surprising and often of high quality. This excitement was shared between the students and the teachers. In some ways the excitement described resembled Csikszentmihalyi's 1996 notion of 'flow' which involves a sense of enjoyment and engagement in a task leading to high levels of achievement. (Csikszentmihalyi, 1996)

Teacher 3 was clearest on this topic:

> 'Whereas, student-centred science projects have a lot more scope for their imagination and investigations … investigating whatever it is that they wish to investigate. Now, that could be something very, very simple with year 7, such as Chain Reaction, which we know about or it could be an extended project qualification

with Year 13 which they can… they can almost do some … almost university standard research into an area of science.' (T3/2/8)

When Teacher 1 was asked to describe what the researcher would see in a lesson she regraded as creative she volunteered descriptions that clearly conveyed her sense that the students would be enjoying the lesson and fully engaged.

GP In terms of what happens. If I was to come in and at the end of the lesson you'd say to me …'That was really, you know… couldn't you just hear the creativity pinging off the walls !' What might I have seen?

T1 Um well, you might have seen the students working together and coming up with ideas… um… creating their own questions… their own answers … they're justifying those answers um… (T1/p6/21)

Teacher 5 identified 'new and exciting' as a characteristic of creative lessons as distinct from the more programmed lesson he would have used for an OFSTED inspection.

'Preparing for an OFSTED inspection rather than creating… being creative … doing something new and exciting for a for a class…' (T5/p2/25)

Another aspect of excitement mentioned was the notion that a creative lesson was an exciting lesson because the teacher made it that way. This 'creativity as performance' is alluded to by Teacher 1 as she described 'the way I teach'.

T1 … if you go into teaching you are quite a creative person in terms of 'how do I get this across to the kids?' 'Do I model it? 'Do I you know…use play-doh?' 'Do I get out a ruler and start building things with it?' You know, you've just got to think outside the boxing I think we are open-minded in terms of coming up with ideas to make it simpler and stripping things back for the students. Yeah, you can't be rigid and boring.

GP So to be creative you've got to be exciting and dynamic and changing or…?

T1 Uh…to me? Yeah, because that's the way I teach … but not everybody teaches like that and you could be creative in just a simple set of questions and you could change the style slightly just to suit your learners so you know, it could be something as simple as that…I suppose creativity is about adapting something something for your students. (T1/p5/32)

Teacher 2 was even more determined to make the lessons 'exciting' and expected, in turn, to be excited by the students and their work.

T2 So this is my, when I'm going away researching, I'm thinking about all the things that I use within lessons and how I can use that to help the students progress so it's sort of getting me firing and thinking about can I make it exciting … how is it exciting to me… how can we make it exciting for each other? (T2/p4/31)

Teacher 6 went much further than any of the others linking almost *any* exciting activity with creativity although she did not detail the reasons for her thinking beyond the suggestion that students like to see things burning and exploding!

> ‘Yeah! And we’d burn something and they got really excited so that’s a kind of creativity really …’ (T6/p13/10)

All of the teachers expected creative lessons to be more exciting than other lessons. They believed that some of this excitement came from their own performance as teachers as they tried to make the lesson interesting, the exposition engaging or use non-standard methods (e.g. card games, small group work, YouTube clips etc.). This was the ‘teacher as entertainer’. A smaller proportion saw students becoming excited because of the work that the students themselves were doing. In this instance the teacher (‘teacher as facilitator’) might have been much less dynamic and entertaining but by giving students autonomy, and so a chance to explore their own approaches and ideas, they produced creative work that was exciting and of a high standard.

There was a universal agreement amongst the teachers that boring lessons were not creative.

The comments from the teachers concerning excitement in the lessons are not surprising. Creative work is often perceived to be enjoyable (Bujacz *et al*, 2016). Indeed one of the arguments against creative work is that it is merely ‘playing’ while real work remains to be done in other lessons (Gove, 2011). What is revealing is the degree of excitement and enjoyment teachers derived from work where they felt they, and their students, were being more creative. This seemed to be a genuine surprise to the teachers and became part of the way the teachers recognised that the lesson had been creative: not all enjoyable lessons were creative (some were merely straightforward but effective, e.g. a well-organised revision session) but all creative lessons were enjoyable. The link between positive emotions and creativity is complex but generally people tend to be more creative when they are in a positive mood than when in a more negative mood (Baas, De Dreu and Nijstad, 2008). Questions of whether the opportunity to be creative generates excitement and positive emotions or whether excitement and positive emotions promote creativity, and the exact mechanisms that link the two, are perhaps moot (Bujacz *et al*, 2016). However, the two do seem to be linked. Again, Csikszentmihalyi’s notion of ‘flow’ (1996) is useful as it describes the all-engaging, task-related state when the person is being both highly effective and happily engaged with their work.

6.9 Construing creativity

6.9.1 Categories as shared constructs

Teachers construe incoming data about their classroom by reference to existing constructs and recognise, or not, creativity in their lessons. How they respond in each situation depends on how they construe that situation. The 46 constructs described earlier give us some understanding of how these science teachers construed creativity.

The categories identified in Sections 6.3 to 6.8 have been developed from a careful reading and classification of these constructs which were, in turn, elicited directly from transcripts and agreed by the original teachers. The categories have also been validated by other raters. All the constructs within a single category share some features in common so, for example, the eight

constructs in the autonomy category are concerned with the teacher's freedom to initiate a possible project and consequent ownership of an activity with a sense of that project reflecting something of that particular teacher.

The categories can be thought of as 'shared constructs' elicited from the analysis of multiple conversations with different teachers. The two poles of the shared construct can then be elicited from the original conversations and the agreed personal constructs. For example, for autonomy:

> **Emergent:** The freedom to choose a possible project and consequent ownership of an activity with a sense of the project reflecting something of the teacher.
>
> **Contrast:** Being directed by others to tasks they wish you to complete without any consideration of your interests, capabilities or ambitions.

This construct is described as a 'shared construct' because it has not been elicited directly from a single person, when it would be a 'personal construct', but has been generated by consideration of conversations and constructs from a number of people. Shared constructs may seen counter-intuitive in an approach called *personal* construct theory driven by a guiding philosophy of constructive alternativism (Kelly 1955) but the commonality corollary (See section 3.3.3.9 The commonality corollary) makes explicit reference to similarities between constructs in different people and makes the point that when this happens their psychological processes will be similar. While we may be alone in construing the world around us we may well be using similar constructs to those used by people around us. Indeed, if we were completely dissimilar in our construct systems useful communication would be impossibly difficult. Table 6.2 shows all the shared constructs with corresponding emergent and contrast poles.

Table 6.2: Shared constructs

Shared construct	Emergent	Contrast
Autonomy	• The freedom to choose a possible project and consequent ownership of an activity with a sense of the project reflecting something of the teacher.	• Being directed by others to tasks they wish you to complete without any consideration of your interests, capabilities or ambitions.
Optionality	• The right to change procedures and methods during a project to reflect growing understanding or a simple change in emphasis.	• Slavishly following a procedure even when it is beginning appear counter-productive or unsuitable as circumstances change. No chance to 'think again' about a problem.
Collaboration	• Students or teachers working together on a project with a degree of mutuality and shared power.	• Groups of students or teachers working in isolation or, when working in groups, being told what to do so that they end up working 'for' not working 'with' others.
Confidence	• Feeling able to take risks and try novel approaches in a situation because the situation does not feel threatening or unfamiliar. Having a sense of personal capability and an expectation of success.	• Feeling unable to stray from safe approaches for fear of failure or censure. A lack of belief in personal capability in this particular area.

Shared construct	Emergent	Contrast
Efficacy	• An activity shows efficacy when students, or teachers, achieve, at least, their intended outcomes (including skills and knowledge validated by examination systems).	• When an activity produces little learning or learning in areas that are not required or valued by the educational context.
Excitement	• The sense of fun and enjoyment an activity engenders both for the teacher and the students.	• A sense of tedious, predictable work that can appear time-wasting rather than enlightening or enlivening.

6.9.2 Enablers, modifiers and validators

PCT suggests that constructs are not passive objects but tools which are actively employed when a person makes sense of the world. The constructs elicited in this study reveal something of how the teachers involved construed lessons as being creative in their context.

Autonomy and optionality are about the personal power of the teacher with autonomy being about their feelings of power to initiate, or reject, projects while optionality is the power to direct a project in the way that seems best to the teacher or student even if they did not have a choice about whether to start the task in the first place. As far as the teachers in this study are concerned, autonomy and optionality allow creative activity to start and persist and so, in the sense that in their absence creativity is not possible, they have a role as enablers of creative activity. Note that the word enabler does not mean, in this instance, teachers with autonomy would be *capable* of creativity (they may be lacking in other areas) only that *without* autonomy creativity is impossible.

Confidence and collaboration are both involved in keeping a creativity project ‘on the road’. Teachers repeatedly stated that they associated confidence to take risks with creative activity and that a lack of confidence could block or stunt creativity. Similarly, collaboration was often mentioned as a part of creativity and the contribution of others was celebrated. Effective collaboration could amplify the creativity of the individuals involved. In these ways confidence and collaboration act as modifiers of creativity in their classrooms.

Teachers described the feeling of fun and enjoyment in the lesson alongside the thrill of creation. This has been captured in the excitement category and acts as a validator of the experience. The other aspect teachers were concerned with was the effectiveness of the lesson in promoting learning. Captured as the shared construct, efficacy, this also validates the creativity.

Table 6.3: Enablers, modifiers and validators

Shared construct	Act as:
Autonomy	Enablers: required for creativity to exist.

Shared construct	Act as:
Optionality	
Confidence	Modifiers: these factors modify the scope and power of the creative activity.
Collaboration	
Efficacy	Validators: confirm that creativity is present in that a lack of efficacy or excitement indicates low levels of creativity.
Excitement	

6.9.3 Interactions

These shared constructs interact with each other in two ways: to recognise examples of creativity and to produce modifications in the construct system. So, a teacher may feel that they have complete autonomy in their choice of topic and how they plan to teach the lesson but are lacking in confidence in that subject or with that class and so they opt for a low-risk, familiar approach with students firmly under control rather than the high-risk, innovative approach with students engaging in exciting and creative activity option that their feelings of autonomy and optionality would enable. One teacher might value excitement (for themselves and their students) more than efficacy whereas another might see efficacy, measured perhaps by examination results, as much more significant than excitement. This will affect their immediate perceptions of an activity (e.g. is it fun? does it cover the learning objectives?) and so have implications for their decision on whether the lesson is creative or not.

However, personal construct systems are plastic. Both the constructs and the relationships between them change in the light of experience (see Section 3.3.3.2: The experience corollary). So, a teacher with high levels of autonomy but low confidence may take a risk *in spite of their worries* and offer more optionality in the process and find, perhaps to their surprise, that students demonstrate both excitement and efficacy, i.e. the lesson was clearly creative. This feedback loop then modifies the role of the confidence construct in the system - perhaps loosening it (See Section 3.3.3.6: The modulation corollary) so that it acts as less of a brake on future action. This is a change in the construct system itself.

Figure 6.4 shows the connections between the three main components. The feedforward arrows (solid lines) show how a teacher's constructs about creativity interact to produce a lesson which they recognise as creative. Given a range of other factors a teacher who feels they posses sufficient autonomy and has enough confidence to take risks, possibly modifying procedures through the lesson, and supported by collaborative colleagues and cooperative students will produce a lesson they regard as creative because it included autonomy, optionality, collaborative work and they felt confident throughout the procedure. Upon reflection the teacher may then recognise that the lesson included a degree of excitement and was successful (i.e it was efficacious). In this instance the excitement and efficacy categories acted as validators of the experience. This will then strengthen their perception that the lesson was creative and that the

‘constructs’ (derived from the categories) are reliable as a way to construe their lesson. This makes it more likely that they will engage in more creative lessons in the future. If the validation feedbacks are negative their confidence may be reduced and their willingness to take risks could be reduced.

Reflection will not be informed solely by the individual teacher. Other teachers may also provide feedback. So, a Head of Department or senior colleague may view the lesson and deem it unsatisfactory. Students may feel they have not learnt anything and communicate this to their teacher or they may simply opt to be disruptive in the lesson. These will reduce confidence and so restrict autonomy (next time you must use the prepared lesson) or optionality (you can’t do that sort of work with these sorts of students). This will tend to reduce creativity.

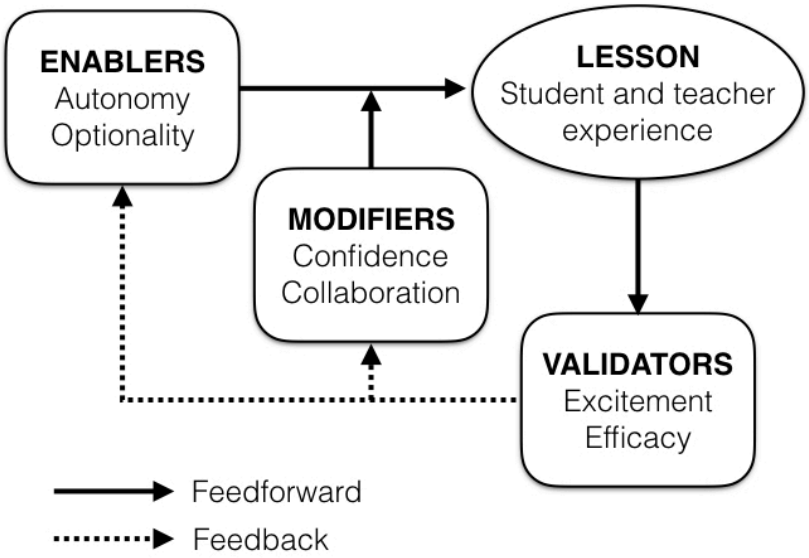

Figure 6.4: Interactions in the EMV model

6.9.4 Constructing lessons

A number of the teachers in their conversations talked of ‘creating’ or ‘delivering’ a creative lesson for their students. They saw it as their responsibility to deliver an experience which allowed students to become engaged and creative and learn the material required by the curriculum or the departmental Scheme of Work. Other teachers adopted a slightly different view talking of students taking ownership of the lesson but they still insisted that, even as they relaxed their degree of control, they were responsible for providing the tools and resources for students to perform.

Given the significance of the teacher in the creation of lessons, a failure to perform any of the roles (Enabler, Modifier or Validator), which impact directly on the teacher’s understanding of creativity, should be noticeable in the lesson experience. Table 6.5 speculates on possible outcomes if particular roles are being met sub-optimally. These could be formulated into testable hypotheses, e.g. in the absence of autonomy or optionality a teacher will tend to produce a ‘safe’ lesson that matches the requirements of their school context but will not be as creative. Note that the labels for the lessons (‘creative’, ’safe’ etc.) and their descriptions are inevitably almost cartoon-level over-simplifications and are not presented as judgements about the appropriateness or value of the lessons but only to explore possible predictions in this discussion of the EMV analysis.

Table 6.5: Effect of role levels in lesson delivery

Ena	Mod	Val	Lesson	Hypothesised resultant experience
High	High	High	The ‘creative’ lesson	This produces the most successful, creative lessons the teachers described when they talked of high achievement and enjoyment with students showing initiative and engagement.
Low	Low	High	The ‘safe’ lesson	Without autonomy and optionality for the teacher or students the lessons are safe, risk-free and acceptable. Little true creativity is experienced but, as students follow pre-written procedures, they can demonstrate success in terms of achieving set learning objectives.
High	Low	High	The ‘surprising’ lesson	These are the ‘surprising lessons’ where a class suddenly and without warning seem to take to a topic and produce amazing, exciting and creative work.
High	High	Low	The ‘failed’ lesson	These are the ‘failed’ lessons - perhaps mediated by a brave teacher. Students are offered a range of options and risks are taken but in the end the lesson does not ‘work’. The output is drab, low-level and generally unsatisfying to either the teacher or the students.

These hypotheses could not be tested with the data available from this study. No measures were developed of Enablers, Modifiers or Validators and no lesson observations were made. However, there were accounts of lessons in the conversation transcripts and, if the logic is valid, then

descriptions of ‘safe’ or ‘surprising’ lessons may appear linked to comments about low Enabler contribution for the ‘safe’ lesson or low Modifier level for the ‘surprising’ lesson. Sections 6.9.4.1 to 6.9.4.4 attempts to find these lessons in the conversation transcripts. If there are indications of these being present it is possible to suggest that a *prima facie* case has been made for further study while accepting that the limited data available cannot offer rigorous vindication of the EMV model.

6.9.4.1 The ‘creative’ lesson

The creative lessons are described by a range of teachers but perhaps the most effusive is Teacher 2 who talked about students taking control (High Ena), working in teams (High Mod), reaching high standards and even surprising themselves (High Val).

> ‘To think about … how can I allow them to be creative? and take away the constraints in my lesson to allow them? How can I put the least amount of effort to get the maximum output from them sort of thing… sort of … And they’re the real lessons where I feel its creative. But allowing them to work in a team, I think … as well is important, I think. Individually, yeah you can be creative but you can never be … reach the full potential you've got unless you’ve got input from other people because you are always constrained by your own …your own mind, I think … so you have to have that team working in that lesson as well, you have to have them working collaboratively and then at the end of the lesson its the sharing of those ideas, sharing them with me, sharing with others and then from that that sparks creativity because then others think ‘oh I didn't think of that’ Oh I didn't think of tackling that question in that way or even I didn't think you could do that …’ (T2/p10/5)

Teacher 1 similarly talked of students working together and confidently (High Mod) driving their own learning.

> GP In terms of what happens. If I was to come in and at the end of the lesson you'd say to me …’That was really, you know… couldn't you just hear the creativity pinging off the walls !’ What might I have seen?
>
> T1 Um well, you might have seen the students working together and coming up with ideas… um… creating their own questions… their own answers … they're justifying those answers um… (T1/p6/22)

Other teachers talked of their performance in terms of providing novelty and excitement (High Val) that encouraged students to be more creative and exploratory using a variety of approaches (High Ena).

> GP Can you talk about what you do to sort of shoehorn a bit of creativity into this…
>
> T4 Um… oh, all sorts… varying it as much a possible really um … So doing things like practicals that link to it … things where …um… students aren't necessarily just … well we do do lessons where ‘This is the information, let’s just get it down in your books’ … writing down notes… but then we also do … um … activities where

they've got to do it so … some of these facilitating idea, so this is what you need to know, here's some information, textbooks, internet whatever …. see if you can pull that together, that information, and find out for yourself … um animations and I get them making video … just as many different ways of them essentially learning the same, not necessarily the same thing, but the same topics but doing different ways … and that's what I feel is my creative approach to it all… how can we get kids to know this? Well, this topic particularly suits going outside and running around on the yard and going 'oh, this is how you calculate speed' . Or this topic particularly suits getting students to present it to the rest of the class because it's three little bits that they need to know and they can research it and pull it together and tell each other about it. That …well I enjoy it really <laughs>

When there was time in the curriculum (High Ena) to be creative Teacher 5 celebrated the chance to do things that were almost archetypically High Val.

'interesting, engaging… uh …. Fascinating, amusing sometimes, but they are different.' (T5/p4/4)

6.9.4.2 The 'safe' lesson

Teachers did identify constraints and frustrations that they felt reduced the opportunity for creativity. For example, Teacher 3 was frustrated by what he saw as over detailed marking procedures. (Low Ena).

'The SLT has decided that OFSTED want marking done in this specific way, therefore it will be done in this specific way …. to hell with how you marked beforehand… it actually then limits the creativity I can bring to my marking uh and the way I assess work because I don't necessarily want to assess work looking for negatives I want to trying to be positive and trying to actually get a student to consider ways in which they answered their whole piece of work not necessarily just one particular piece I've picked out…' (T3/p8/16)

OFSTED inspectors also appeared in comments from Teacher 5 as he explained that he would opt for safety, (Low Ena, Low Mod) doing less exploratory or creative work, when inspectors were due to attend:

'I've done three or four OFSTED inspections..now maybe five, I'm trying to remember. All of them have been … uh… not entirely functional but more functional … um … preparing evidence of things which is there … just collating evidence, maybe documenting things that in a specific form that you already have in a different form … um… and making sure everything in order essentially. Doing a bit of housekeeping. Doing a bit of tidying up. Preparing for an OFSTED inspection rather than creating… being creative … doing something new and exciting for a for a class…' (T5/p2/25)

6.9.4.3 The 'surprising' lesson

While most of the proposed lesson types when a key category is missing is a less than optimal lesson sometimes teachers can be pleasantly surprised by the way students respond. Teacher 1 described her nervousness (Low Mod) about a particular lesson with one of her classes and the surprising outcome. (High Val)

> 'And I thought, you know, are they gonna behave while they do this? Are they going to be able to push themselves where they're creating questions and actually analysing what they've got to give the answer ? So I thought, no I wanna try it. So trust them. And actually it's one of the best lessons ever and they've learnt so much from it that I got two lessons into one. So I think that that was a really creative lesson.' (T1/p8/19)

6.9.4.4 The 'failed' lesson

Descriptions of 'failed' lessons are rarer but this was not unreasonable given that the conversations were intentionally positive and supportive in their nature and the teachers were aware that 'a researcher' from 'a university' was present. Despite assurances that none of what was discussed would find its way back to Heads of Department it is not unreasonable to assume that teachers were less than enthusiastic about sharing information that showed them in a light which could be interpreted as negative.

However, there were shadows of lessons that did not 'work' for teachers. A number talked of the 'risk' involved in seeking to operate creatively and this implies that they have taken risks in the past and the lesson has 'failed' - either through the activity descending into chaos or the specific learning outcomes required not being achieved (Low Val).

Teacher 3 explained about the pressures of developing lessons at the forefront of their own personal knowledge and the willingness of their students to critique these lessons. This suggest that the levels of Validation are constantly under threat from some classes.

> 'Um so so I'm going back to my … you know my university textbooks to try and be one step ahead …um… of the group and that is actually forcing me to be quite creative when I teach that because I've gotta actually find a way that I teach myself at the same time as I'm teaching these students and we're very much collaborating in each others' learning at this point because, whilst I'm trying to teach them they're also acting as my …uh…if you like my focus group who are able to tell me whether this resource or this lesson works or not and, you know, if you've got a year 13 who's six weeks away from their A star <the highest grade available in an Advanced Level examination> that's going to get them into med school they're gonna tell you if they think what you've just put on for them is a load of rubbish.' (T3/p4/26)

6.10 Limitations of the study

The study was situated in a limited number of English schools with science teachers working at a particular level. This was to ensure practicability in the time available for a PhD study and to allow

an in-depth exploration of the constructs they used when thinking about creativity in their own practice. The teachers were chosen because they had expressed an interest in creativity either to their Heads of Department or in other meetings with Sheffield Institute of Education (e.g. Continuing Professional Development courses or involvement in other SIOE projects). This means that they were not necessarily representative of science teachers as a whole and so conclusions about creativity are not immediately generalisable across the wider science teacher community. However, this study did not set out to provide generalisable findings for the whole science teaching community, which would have required larger samples with more extensive testing and trialling, but to develop a rich picture of the understanding of creativity of a group of science teachers in their own classrooms using in-depth, qualitative measures that allowed their voices to shine through.

So, while not being, or claiming to be, classically generalisable the study is one that other teachers and educators might find 'relatable' (Bassey, 1981).

> 'I submit that an important criterion for judging the merit of a case study is the extent to which the details are sufficient and appropriate for a teacher working in a similar situation to relate his decision making to that described in the case study. This relatability of a case study is more important than its generalisability.' (Bassey, 1990. p 85)

He cited a specific example (using the Cosford Cube as a way to provide immediate, formative feedback for the teacher) and offered five criteria for assessing relatability:

- Could I do it [the teaching procedure]?
- Would it be suitable for my students?
- Would I use it as often, more or less [than the current approach]?
- Would my students appreciate it?
- How would my students fare [if I used this procedure]?

Using these questions and considering providing more optionality as an example of a teaching approach to increase creativity in their classroom, a teacher could certainly consider offering their students more optionality during lessons if they considered it appropriate. They would have ideas about how often they might use this approach based on their understanding of whether their students would appreciate it and what effect it might have on their learning. Similar arguments could be made for other factors, for example teachers could choose to work more collaboratively, value excitement in their students and themselves more highly and so on. All of these suggestions come directly from the six categories identified in this study.

The argument for relatability has been picked up by Kvale (2011) when he talks of 'analytical generalisation' as an alternative, or addition, to statistical generalisation.

> 'Analytical generalization involves a reasoned judgement about the extent to which the findings from one study can be used as a guide to what might occur in another situation. We may here discern a researcher-based and a reader-based analytical generalization from interview studies. In the first case the researcher, in addition to

> rich specific descriptions, also offers arguments about the generality of his or her findings. In the latter case it is the reader who, on the basis of detailed contextual descriptions of an interview study, judges whether the findings may be generalized to a new situation.' (Kvale, 2011. p 127)

Kvale's comments only apply to studies which have already been shown to have produced rigorous, valid data (see Section 4.5.5 Validity for details about the validity of the methods used and data collected in this study). A case can be made for the 'analytical generalisability' of this study: it was conducted in a rigorous manner, described in detail in Chapter 4: Methods, produced valid data and a set of findings which are compatible with, and extend beyond, existing literature. Even though the sample was modest, with only seven participants, this allowed a detailed interaction with all, including two interviews with each of them. The data collected was valid and representative of their constructs and feelings. The constructs elicited during analysis were also repeated across the group implying that neither the teachers nor the constructs were idiosyncratic.

The second aspect of analytical generalisability, namely the reader's judgement that the study has relevance to their situation, depends on any potential readers judging the teachers and classes involved to be familiar or, at least, compatible with their own specific situations. The teachers involved in the study were not an unusual group in that, within the time constraints mentioned above, they came from a cross-section of schools and included a balance of subject specialism, departmental seniority and teaching experience. In terms of gender balance the seven teachers included only two females which is not representative of teaching as a profession. A third female teacher was involved in a conversation but it became impossible to follow her up in a second conversation for work reasons (she moved to a job in a school on the other side of the country) so her conversation and constructs were not used in the analysis. Furthermore all the teachers were working with typical students, although the students at the selective school were possibly skewed slightly towards the higher end of the ability spectrum, and all were following standard courses (none were following specialised courses like Electronic Physics or qualifications like International Baccalaureate which are unusual in England).

While the report of the constructs and the categories is robust and likely to be applicable to teachers beyond the sample the EMV model has less direct evidence to support it given that the data collected did not seek to test the predictions generated from the model. However, indications from the lesson descriptions present in the conversations do support the model to some extent and suggest further study would be valuable in this area.

Furthermore, the EMV model has already been used by the researcher in a number of CPD sessions with science teachers and university lecturers to help them reflect on their teaching. At the present moment experience of using this technique is limited but in one example from a workshop in Kochi, India (RBPT, 2017) a group of teachers explored the issues around autonomy and optionality (captured in the model as 'Enablers'), their degree of collaborative working and their confidence as teachers (Modifiers) and even how they could recognise excitement and efficacy (Validators) in a system that was already heavily endowed with formal assessments. While

the discussions were informal with small groups and not part of formal workshop programme and concerned inquiry in the first instance rather than creativity, the discussions were useful and provided an alternative way to consider the issues raised in the main workshop sessions.

6.11 Suggestions for further work

As described above, the sample chosen for the study was highly focused on teachers with an interest, and expressed capability, in creative work in science at secondary school level. While the constructs were largely shared across the sample, implying a degree of validity, the study could usefully be extended both downwards to primary and to other science teachers who are more representative of the teaching population in general as opposed to those who express an inclination to creative practices. Even teachers who would not claim to value creativity particularly in science lessons will still be operating with a view of creativity, and consequent personal constructs, and it would be instructive to find out if these were significantly different from the teachers involved in this study.

A significant difference between secondary school science teachers and primary teachers is that the former are generally specialists who have received extended training in science and in the techniques of teaching science whereas the latter are generalists who might have done a degree in a science subject originally but whose training would have involved much less science and much more literacy and numeracy. This difference could have a significant impact on the constructs applied to creativity in science. The EMV model may be even more susceptible to differences between science specialists and teaching generalists given the significance of 'confidence' in the Modifier role. Exploring the validity of the model with primary teachers who may be lacking in confidence with the meaning of science concepts, but equally with greater confidence in handling their students, due to more time spent with their own group, would be instructive in picking apart the linked effects of subject knowledge and student familiarity.

The EMV model generally makes a number of testable predictions concerning the nature of lessons created by teachers with different degrees of EMV role delivery. The current study did not specifically set out to test these hypotheses. However, the presence of recognisable versions of the different lesson types implies that the model has some validity. Further work isolating key variables (e.g. level of Enablers, perception of Validators) in a quasi-experimental approach looking at lessons generated by the teachers would provide stronger evidence of the validity and utility of the model.

6.12 Reflection

Chapter 6 draws together ideas from the literature review, data from the study and reflections on the meaning of that data to create some new insights. The grouping of the constructs into categories made it much easier to think about these meanings - keeping 46 constructs, each with two poles, in your head at one time is almost impossible. Reflecting back on this process it is instructive to see how the analysis was not a simple, one-step conversion of conversations into

constructs but a logical sequence where the output of one stage (conversations to constructs) provided the raw data for the next stage (constructs to categories). Indeed, much of this study was a constant examination and re-examination of data until a useful output became apparent.

So, for example, the initial clustering of constructs into categories took place on two separate occasions (to allow time for reflection and potentially new insights), and although the changes between these two classifications were minimal, this two-step process identified an issue with the distinction between autonomy and optionality. This was not surprising given that the visible behaviours (teachers making choices) might appear very similar in both cases. The recognition, on re-reading the transcripts, that autonomy was more about personal choice and control while optionality was concerned more about procedural choices provided the breakthrough when deciding where to place individual constructs. This distinction was subsequently confirmed by reading of the literature (Bujacz *et al*, 2016).

The tension between teachers wanting complete autonomy and optionality for themselves but being comfortable about limiting the same for their students was not surprising. Much more surprising was the insistence amongst teachers that creative lessons, which depended upon autonomy and optionality, were lessons where students learnt a lot - the notion emphasised in the category 'efficacy'. This appears to run contrary to much of the advice from the UK government at least who have been encouraging a move to a more structured and controlled pedagogy, termed 'direct instruction' (Stockard et al, 2018), on the grounds that it is more effective. The arguments concerning 'direct instruction' as opposed to more open pedagogies like guided instruction or open discussion have been going on since Dewey talked of student 'experiences' (Dewey, 1897) and are unlikely to be settled in the near future.

The categories also provided a useful way to formulate 'shared constructs' which had some of the properties of Kelly's personal constructs. Significantly, since Personal Construct Theory claims that constructs are used both to interpret the world (recognise replications) and to guide behavioural responses to it (Kelly, 1955) it was possible to reflect on how the categories were acting to recognise creativity and guide teachers' responses to situations where creativity was evident. Identifying groups of categories which appeared to have similar roles in terms of recognising and responding to potentially creative situations produced the EMV model. Again, this is an example of how I 'looked again' at the original dataset and its derivatives to generate new insights. Coming from a more deductive, scientific tradition where data are usually collected to address a specific issue and often used once to confirm or reject a hypothesis this return to the data and re-analysis was surprising and enlightening.

The EMV model provides a way to move from simply describing teachers understanding of creativity, initially the key issue in this study, to suggesting ways to develop their practice of creativity. While the comments in the literature about the lack of creativity in classrooms identified a lack of understanding of creativity (Gralewski and Karwowski, 2016) an alternative approach is to suggest that teachers have an understanding of creativity but that this understanding stimulates little progress or experimentation. If creativity was perceived to be all about, for

example, practical work (Kind and Kind, 2007), then once you had included practical work in your lesson plans the creativity issue was solved and the pressure to develop further effectively disappeared. If that practical work was simply a slavish implementation of a detailed guide provided by curriculum developers or commercial publishers it is difficult to see it as very creative. The independent skills assessments (AQA, 2014) formerly used to assess Sc1: Working scientifically fell into this 'practical' but not 'creative' experience for many teachers and students. It looks more like compliance. In comparison, the EMV model provides a dynamic model which shows how the components that teachers use to recognise creativity. The feedback and feedforward loops in the model means it responds to any circumstance and, provided autonomy and optionality are present, will tend to encourage further experimentation. So, as soon as teachers take a risk (supported by a collaborative environment or their own personal confidence) and do something different (i.e. novel) they will use the notions of excitement and efficacy to decide if it works (effectively they will apply value criteria). If the initiative yields an encouraging result the teacher moves forward, if it yields a disappointing result the teaching strategy will be modified. Since there is no predefined endpoint beyond excitement and efficacy, unlike the 'practical work' or 'small group work' reported by Kind and Kind (2007), the model tends to encourage further experimentation and so creativity. I was encouraged that the limited data available from the conversations appeared to support this (see Section 6.9.4).

Chapter 7 formalises conclusions for the whole study and discuss possible implications of the conclusions for teachers, educational systems and governments.

Chapter 7: Conclusions and implications

7.1 Introduction

Chapter 7 will revisit the original research question and summarise the conclusions from the study and explore the implications of these for researchers, teachers and schools.

7.2 Research question

The original research question for this study was 'What do science teachers understand when they talk of creativity in their science lessons?' For reasons given in Chapters 2 and 3 this was not simply a search for another definition of creativity honed for specific deployment in science lessons but a desire to understand how science teachers recognised and experienced creativity in their lessons. Through the use of a Personal Construct Theory methodology this study has identified that science teachers do have an understanding of creativity in their lessons but that it differs in emphasis from the issues raised by researchers.

The science teachers in this study perceived creativity as being fundamental to their work with students and revolved around six issues concerned with how they recognise creativity. These issues were autonomy and optionality (the enablers) to provide creative potential, confidence and collaboration (the modifiers) to support delivery of teaching that supported it and excitement and efficacy (the validators) as ways to judge the success of the approach. They perceived an interplay between these factors and could describe in detail how they could support, or inhibit, creative experiences in a science context in their normal teaching and learning strategies.

The sections that follow summarise the key conclusions and implications of these insights for the understanding of creativity amongst researchers, teachers and schools.

7.3 Construing creativity in the classroom

7.3.1 Recognising creativity

During discussion with seven science teachers 46 constructs were elicited and, taken together, these provide a view of how these teachers recognise and experience creativity in their classrooms. Although the sample was relatively small the methodology was in-depth and the constructs produced showed a degree of commonality across all the teachers involved suggesting none were bizarre or idiosyncratic.

The constructs were also compatible with the existing literature definitions of 'novelty and value' (Sternberg, 1999) even if the emphasis was slightly different (See Sections 6.3.2, 6.4.2, 6.5.2, 6.6.2, 6.7.2 and 6.8.2 for the relevant discussions).

The 46 constructs were provided in full in Section 5.4: Construct listing and will not be listed again here. The constructs were readily classified into six categories: autonomy, optionality, confidence, collaboration, efficacy and excitement. These ranged across issues of personal power (autonomy

and optionality) through practical, technical factors (confidence and collaboration) through to output measures (efficacy and excitement).

The six categories provide a useful picture of how teachers construe creativity in their teaching experiences. If teachers, looking at what happens in their classrooms, perceive that they, the teachers, are driving developments (autonomy) and modifying procedures intelligently as they make progress (optionality), feel confident in what they are doing and can see students excited by the work and learning effectively from it their construct system recognises this experience as an example of creativity. Alternatively, if they perceive that they are simply told what to do, offered no options, work alone or in competition with others on drab and pointless tasks they would not regard the activity as creative.

The two descriptions in the previous paragraph are clearly extreme ends of a spectrum and most classroom activity will fall somewhere between the two ends with a consequent degree of creativity rather than a perfect match/mismatch. The more constructs that are involved in replication of the data and the more the data collected are mapped towards the creative end of the construct (e.g. more autonomous and less controlled) the stronger will be the conviction that what is being experienced is ‘creativity’.

It is notable that, although teachers were universally concerned about their right to teach in a particular way (autonomy), few made comments about specific teaching approaches (pedagogy). Even where teaching schemes and approaches were agreed collaboratively (a construct they used to recognise creativity) they insisted, some even with a sense of pride, that they must be able to personalise the agreed approaches and teach in their own way.This refusal to abdicate personal control may have significant implications for teacher trainers and curriculum developers who are seeking to encourage more creativity in science classrooms. Perhaps it is less about telling teachers what to do (even if the teachers approve of the messages) and more about allowing teachers to make their own decisions.

7.3.2 Refining constructs

Kelly (1955) stated that constructs are not fixed objects. They develop with us as we experience more of the world. They are used to construe the incoming data (we recognise phenomena because they replicate similar previous experiences) and we behave appropriately based on how the world responded the last time we made a similar set of replications. Chapter 3 describes the mechanisms of PCT in detail so they will not be rehearsed here. Simply put, where the responses suggested by our construct system are adaptive and useful the relevant constructs are strengthened (because they ‘work’) but if the world becomes more hostile or confusing the constructs are weakened or reconfigured into new constructs (because they ‘did not work’).

The EMV model, described in Chapter 6 and so not repeated in detail here, suggests a way to understand how these changes might occur across the six categories. Teachers who perceive high levels of autonomy and optionality (Enablers) in their situation will have the potential to act creatively and are part way to recognising the phenomena in front of them as being creative

(effectively they have produced replications for two of the six construct categories). If the lesson they are considering proves to be exciting and effective (the Validators of the EMV model) their constructs relating to creativity will be strengthened. However, if, when given autonomy or optionality the resultant lesson is poor or chaotic their construct system will tend to revise itself to take this unexpected result into account.

The Modifiers (confidence and collaboration) provide fine tuning of the system. They can amplify a perception of creative potential and consequent action when teachers are feeling confident and are working in a collaborative environment. However, an isolating and judgemental environment can have the opposite effect. The modifiers are also the constructs that are most susceptible to reconfiguration - confidence can rise as a result of validation (an exciting lesson that achieves its ends) or be crushed by a lesson which 'failed'. Teachers new to the profession may be particularly susceptible to these sudden changes as they seek to develop their own personal teaching skills and strategies. A single 'failed' lesson can be very disheartening when you do not have experience of years of 'successful' lessons and may even be considering if teaching is the right career for you. More experienced teachers may be more resilient and so better able to understand that a particular lesson 'failure' may have been due to a range of factors and not due to their teaching strategy which they have developed over years.

Changes in teachers' understanding of creativity in their lessons probably depend more on changes in modifiers and validators than on enablers. The enablers (the levels of autonomy and optionality) may well be set by external agencies and reviewed very rarely, e.g. at a change in departmental head or following an OFSTED inspection. Validators (excitement and efficacy) have a short-term and long-term element. The short term element is the teacher's individual perception - as they watch the students leave the classroom at the end of the lesson they will have a feeling of whether the lesson went well (was it exciting? did the students learn a lot?) which will contribute to recognition of the creativity present. However, formal validation (through marks generated by the teacher or external assessments) may appear days, weeks or even months later. The modifiers have a more routine impact. Teachers will immediately know if they feel confident with this particular subject or group and will modify their lesson plans and practice accordingly. Similarly they will be aware every day if they are in a collaborative or isolating environment. Confidence probably applies to individual subjects or groups and so generates modifications at a very granular level whereas collaboration operates at a grosser scale. If validators have two time-defined facets (short and long-term) so modifiers have two granularity-defined facets (single group/topic and general ethos of the department).

Also, while teachers' constructs may change over time, indeed this is the basis of PCT as a therapeutic tool (Kelly, 1955), the EMV model should remain unchanged as it describes the generalised roles (enablers, modifiers and validators) involved in reflection about lessons rather than the individual content of a specific personal construct. This emphasises its value as a tool to reflect on the understanding of what constitutes a creative lesson.

7.4 Creativity and teaching

While the conversations in this project were designed to allow elicitation of the underlying personal constructs they also provided a chance for teachers to speak of creativity more generally. None found it difficult to discuss creativity in a productive way and most volunteered that they had enjoyed the opportunity to have the discussion. More than one explained that it was good to have time to reflect on their ideas away from the everyday demands of teaching. It was noticeable that all of the science teachers in this study clearly valued creativity in their students and all expressed the hope that they were, as teachers, creative.

The teachers regarded creativity in science lessons as valuable for learning but often undervalued by school systems (e.g. assessment regimens were perceived to emphasise memory rather than creativity), motivating but sometimes demanding (e.g. allowing students to be creative could lead to the class fragmenting into a myriad of possible activities) and often to do with performance and communication skills (e.g. posters and presentations) rather than the generation of new ideas. In many ways, the teachers spoke of creativity in the same way that they talked of 'good teaching' and inquiry-based lessons with an emphasis on students being active, engaged and often working above their expected levels. This reflects perceptions in the literature summarised by Kind and Kind (Kind and Kind, 2007).

The teachers described individual lessons, or even whole student groups, which they regarded as creative with some warmth. Whether they like these groups because they were creative or they were allowed to be creative because the teacher liked them was not always clear. Creativity was certainly seen as involving a risk and teachers were not willing to take that risk with classes who were demanding or difficult or who faced imminent examination pressures.

Where teachers quoted examples of creative work they typically involved the use of skills and knowledge that would be seen traditionally to be outside the domain of science. A number talked about posters and presentations or other novel ways to showcase science understanding (e.g. online video clips), others talked of group work using sophisticated team skills. Few specifically mentioned science content as a route to creative work - more often the required content and the curriculum were seen as burdens which reduced creativity rather than an opportunity and stimulus to develop it.

The current study also showed that teachers feel a strong responsibility for the lessons their students participate in and, specifically, see creativity in their students as being to some extent dependent on what they, as teachers, permit or reward. In turn, they felt their performance which involved making the topic interesting, by which they often meant an entertaining delivery by the teacher, and, more rarely, allowing digressions into student-generated topics, was severely constrained by curriculum and assessment demands and the need to manage their classrooms and student behaviour. A constant refrain concerned their lack of time and freedom. A number suggested that school policies also inhibited creativity.

7.5 Original contribution to knowledge

While this study has explored areas that are claimed to be of fundamental significance to educational systems (see Section 1.2: The significance of creativity) few prior studies have spoken directly to teachers in an unstructured and teacher-centred way that allowed their voice to emerge. A number of studies have looked at teacher understanding of creativity in terms recognisable to researchers (e.g. fluency, flexibility) few have offered, and required, teachers to consider their own understanding of creativity unnumbered by prior definitions of the concept. Indeed, 83% of 612 studies on creativity between 2003 and 2012 used quantitative methodologies, predominantly psychometric, leaving very little space for in-depth conversations with teachers. (Long, 2014)

For this reason, the current study did not seek to provide another definition of creativity specific to the science classroom or describe, and test, creativity as experienced by science teachers. I decided instead to listen to science teachers and record their observations and understandings about how they recognised and experienced creativity in their lessons and so gain a route to understanding their understanding of creativity. The reasons for choosing Personal Construct Theory to frame the study were given in Chapter 3 Methodology but the key factor was that PCT allowed me to understand more clearly the teachers ways of thinking and understanding than a simple classroom observation approach would have allowed. Effectively, PCT has allowed me to look beneath the characteristics of creativity defined by researchers to explore constructs used by teachers themselves to construe their own experience of creativity. The method used in the study was modified from the classical PCT approach in that it used two conversations rather than one and the constructs were elicited through analysis of the conversations transcript independently of the teacher. The second conversation allowed the constructs to be confirmed, and clarified as appropriate, so providing an even greater degree of insight into the teachers' thinking compared with standard PCT as well as good respondent validity.

The study produced a catalogue of 46 constructs used by science teachers in England teaching students in the 11-16 age range. These 46 were classified into 6 shared constructs spread evenly across all teachers involved. The six shared constructs could, in turn, be sorted into three groups (Enablers, Modifiers and Validators) depending on their roles in the teachers understanding and experience of creativity in their classrooms.

The EMV model, described in Section 6.9: A model of creativity, is presented as a way to explore the factors that impact upon teacher creative performance in lessons. It is based on constructs elicited from teachers and can be used predictively to generate testable hypotheses. The limited data available in the original teacher conversations suggest that the model has some validity but further work is needed to strengthen this case. This will be discussed in Section 7.6 Implications for research and practice.

Even without further support, the EMV model provides a useful way for teachers to reflect on their own creativity in the classroom. It identifies potential factors which have an impact on their construing of creativity and so allows them to reflect on these in a more conscious and directed way. It may be that encouraging teachers to consider the role of collaboration or validation in their

experiences of creativity will help to drive action and development where a simple ‘How creative do you think that lesson was?’ might produce more diffuse and difficult to action perceptions.

7.6 Implications for research and practice

7.6.1 Implications for creativity researchers

As has been noted elsewhere (Mullet, Willerson, Lamb and Kettler, 2015) there is a mismatch between the understandings of creativity between teachers and researchers. This study found the same effect with teachers talking of ‘autonomy’, ‘excitement’ and ‘collaboration’ rather than the ‘fluency’ and ‘fluidity’ common in much of researchers’ discourse. ‘Creative’ in the minds of the teachers involved in this study seemed to be a synonym for ‘interesting’ or ‘exciting’. Researchers studying creativity in the classroom need to be aware of this mismatch in language use and consider if, in fact, the word ‘creativity’ is used to label completely different things in research and classroom teaching. The differences in words used (Mullet *et al* 2015), catalogued in Table 1: Words used to describe creativity, are not insignificant.

Table 1: Words used to describe creativity.

Words used to describe creativity		
by researchers	**by teachers (in literature)**	**elicited from teachers (in this study)**
Playful	Imaginative	Autonomy
Open to new experiences	Artistic	Optionality
Critical	Intellectual	Collaboration
Emotional	Independent	Confidence
Stubborn	Unique	Excitement
Risk-takers	Curious	Efficacy
Curious		
Impulsive		
Adventurous		
Non-conformist		

Table from Mueller *et al* 2005

The mismatch in vocabulary used may be simply the use of different words for the same concept. While this would be inconvenient, a simple translation would solve the problem. However, the nature of researcher’s interests and understandings seem conceptually different from teachers’ concerns. The researchers were concerned with the aspects of creativity as measured by creativity tests (fluency, flexibility) and personality correlations (non-conformist, adventurous, risk takers) whereas teachers in this study were more interested in context issues related to their day-

to-day work experiences (confidence, collaboration, excitement, efficacy) and their power within the system (autonomy, optionality).

This disconnection means that much of the conversation between teachers and researchers runs the risk of being less than optimally productive. This also has implications for any training or support that researchers may develop to support teachers as they seek to encourage more creativity in their classrooms. Research is needed to gather more sense of teachers' understandings and experience of creativity. This research could involve teachers from different age ranges (e.g. primary, secondary, higher and further education) or different subjects (sciences, mathematics, arts, humanities) to find out if there are common threads running through science and art teachers' perception of creativity.

The EMV model also merits further work. Based on the existing data it is potentially an interesting way to start looking at creativity in classrooms but it will need further development, possibly through a more experimental approach looking to support or reject the tentative hypotheses developed in Section 6.9: A model of creativity.

7.6.2 Implications for teachers and schools

Science teachers are no clearer about the exact definition of creativity than many others. It remains an essentially contested concept (Gallie, 1955) and yet the current project shows considerable overlap in the constructs they employ to understand creativity (autonomy, optionality collaboration, confidence, excitement and efficacy). These constructs provide a useful way to identify gaps in creativity understanding and, potentially, behaviour amongst science teachers. This, in turn, provides a strategy to build both. If autonomy is a key construct it should be possible to identify strategies which will build it and so increase creativity. Table 2: Strategies to improve explores these strategies and identifies aspects of teacher experience that may work against its development.

Table 2: Strategies to improve

Shared construct	Strategies to improve
Autonomy	• Allow teachers to make decisions about sequence and content of their lessons rather than following externally-created Schemes of Work • Allow staff and students to define personally significant problems rather than simply following pre-built problems identified externally.
Optionality	• Support practical work through good facilities (laboratory, chemicals, time available). • Celebrate non-standard or surprising insights and methods rather than insisting on existing approaches. • Provide time for authentic explorations leading to significant results.
Collaboration	• Operate in teams and build mutuality between all members of school staff (and students). • Use staff meetings for discussion and policy development rather than only as means to distribute information and requirements from senior management.

Shared construct	Strategies to improve
Confidence	• Identify issues which build or reduce confidence for teachers when engaging in creative work. • Build strategies to support teacher confidence as they work outside their original discipline areas, with unfamiliar classes or in ways with which they were previously unfamiliar.
Efficacy	• Explore and implement other methods of validating work, particularly creative work, rather than test results (for teachers and students).
Excitement	• Allow students to explore their own ideas. • Celebrate non-standard or surprising insights and methods. • Provide time for authentic explorations leading to significant results.

Many of the suggestions in Table 2 would involve changes in policy, provision and practice in schools. Many are directly concerned with the extent to which teachers can make decisions about their own lessons without being forced down routes decided by others in the form of departmental schemes of work, school management, national teaching guidelines or strategies or the requirements of assessment instruments. Returning a degree of freedom to teachers might be more significant in terms of increasing the level of creativity in science lessons than a number of top-down creativity teaching packages. Few of these changes are likely to be straightforward or uncontentious. However, if creativity is as significant an issue as claimed in Chapter 1, to avoid, at least, having discussions about these issues could severely restrict options for science students and societies dependent on high-technology industries.

7.7 Reflection

Reflection on the broad conclusions of this study requires more than simply a re-statement of the key findings. To suggest that researchers and teachers are somewhat disconnected in their thinking about creativity demands that one, or both, parties seek to do something about this. Similarly, if, on reflection, many of the issues to do with creativity in science lessons revolve around the limited power of the teacher, relative to other actors in the system (See Chapter 6), and creativity is a key feature of science (See Chapter 1), then an attempt to reduce those power differentials seems essential. Comments reported earlier concerning over-stuffed curricula, and obsessive assessments (Compton, 2010), curriculum narrowing (Berliner, 2011) and the pressures on teachers that are leading to a drift out of the profession at every level (Hilton, 2017) suggest that this change in the power balance is not occurring - at least in England.

Furthermore, construct systems are not static objects. New data are being constantly interpreted by the system and, in the process, changing the constructs in the system and their interrelationships. This means that the understanding of creativity will change. Teachers' recognition and experience of creativity in their lessons is not like remembering the melting point of sodium, a fact that I have kept in my head since the age of 15 (it is 98 degrees Celsius). It is

understanding that is being constantly updated and developed. Indeed, this is the basis of much PCT work in a therapeutic context.

When teachers' experiences support their constructs and construct system they behave in ways that they recognise as being creative. This is a self-reinforcing, virtuous circle. However, this plasticity of constructs and flexibility of the whole construct system also means that teachers' recognition and experience of creativity can be eroded if their attempts to recognise creativity in their lessons are constantly frustrated. Many of the teachers in this study spoke of the limitations imposed by the school and wider educational system (e.g. OFSTED, high content load of curricula, time available, departmental policies) and cited these as problems with being more creative. If these limits were merely static problems impinging on classroom activity that would be unhelpful but it would not reduce the teachers ability to *recognise* creativity. However, when a particular construct is routinely impacted negatively (e.g. restriction of autonomy, efficacy defined purely in terms of public examination results) the effect spreads beyond that individual component. There is a general revision of their understanding of that construct's usefulness and a shift in the whole system to create different perceptions of creativity and so a reduction in the potential for further creative development. For example, if departmental meetings are claimed to be opportunities to enhance creativity through collaborative working but are perceived by teachers as purely about transferring information from the senior management team, mundane housekeeping regarding kit or assessment requirements, the teachers may begin to question the usefulness of collaboration in their view of creativity. They may opt instead for more individualistic approaches with implications similar to those described by some in this study 'I do not use other people's worksheets' and 'We are all just waiting for the meeting to end'. This is the vicious circle that is the perfect mirror to the virtuous cycle mentioned above. If instructions delivered by a well-meaning Head of Science or creativity consultant are seen simply as directives from senior management they are unlikely to support significant implication for teacher development (particularly in the area of creativity) . This calls into question the simplistic use of 'creativity techniques' as a way to build creativity in schools.

Therefore, any attempt to improve the understanding and experience of creativity, for teachers and ultimately students, must adopt a systemic approach tackling a number of factors (e.g. time, skills, class size, assessment schemes) but primarily the enablers in the EMV model: the teachers' autonomy and their right to manage their own lessons (optionality). The alternative is not to stand still in terms of teacher understanding of creativity but to see a gradual, hopefully marginal, erosion of that understanding with a consequent fall in the education system's ability to innovate.

Postscript

Po1 Looking back

This PhD began as an exploration of creativity in the science classroom - or, perhaps more accurately, as an exploration of Gareth Price's understanding of creativity. I started knowing that what I did know was confused but sufficiently robust to just about hold together in discussions about curriculum development and teaching. My understanding was based on years of experience and a degree of unstructured reflection.

The PhD has allowed me (forced me) to reflect much more rigorously and to research the understanding of others more carefully. It has equipped me with a number of specific research skills and a familiarity with the existing literature and thinking concerning creativity. The process has also been exciting, infuriating, exhausting, enlivening and deeply depressing at various stages. A PhD is, by its nature, a long haul, particularly when it is done part time in the gaps left over from other full-time employment. I can easily understand why more PhDs are abandoned than failed.

Po2 Revisiting the definition

The Preface contained a definition of creativity in science education that drew from my own experience and understanding and available literature. It uncontroversially included notions of novelty and validity and was followed by a series of bullet points that followed clarified details. This is reproduced below.

> Creativity in science education involves the production of novel ideas, approaches or objects that serve some purpose or have some value in the context of engaging learners with, or developing, scientific domain knowledge and practices.
>
> - Creativity in science education can include the production of ideas that would be recognisably scientific (e.g. testable claims about the rate of reaction of calcium carbonate with different particle sizes) or objects which communicate scientific insights generated elsewhere (e.g. posters, presentations, talks about experimental results of a science topic)
> - Creativity in science lessons can be exhibited by teachers (in terms of novel pedagogical approaches) and students.
> - The 'value' ascribed to creative outputs in science education will typically be focussed on student attainment or engagement.
> - 'Novelty' in science education could mean 'novel to the students' as much of the material to be covered is already known within the wider scientific community. However, in some instances students will create insights or data that is novel on a wider scale. e

- ‘Novelty’ could also mean ‘novel to the teacher’ where they are developing new teaching approaches but covering well-known domain knowledge.

Nothing in the definition has been contradicted by the research in this study. I have seen examples of novel ideas, approaches and had reports of worksheets and software that teachers have claimed as examples of ways they have been creative in their teaching. I have also heard of students producing work of high value, often in response to non-standard lesson plans and circumstances. The nearest any conversation came to teachers, or students, producing insights which were novel to the general scientific domain was talk of ‘university level work’ in AQA Extended Projects (see Section 5.3.3.1). This is hardly surprising, at ages 11-16 most students would not be expected to produce material that was truly new to science.

While nothing has contradicted the definition or the bullet points that follow the focus of the research rapidly moved towards other issues as a result of the conversations with the science teachers. Teachers did not want to talk about novelty or value particularly but they were exercised about autonomy and optionality, they did talk about collaborative working environments and their confidence in the classroom. These issues seem to link to novelty. If you are merely repeating approaches and lessons you have done before (i.e. limited or no novelty) you do not need to exercise autonomy or optionality particularly and you have confidence because you have been this way before (there is limited or no risk). The fact that teachers talk about the need for autonomy and optionality implies that they are entered uncharted territories and aiming for ‘novelty’. They emphasised excitement and efficacy as aspects of authentic creativity - arguably an unpicking of the ‘value’ in standard definitions. This makes me think that the definition of creativity is concise, accurate and resilient but ultimately less helpful than the teachers’ constructs about it in their classrooms. These constructs help us to understand what they really think and, crucially, provide indications of potential changes to the education system that will make creativity more likely in science lessons.

When I began this journey my first inclination was to develop and trial resources and techniques for teachers to aid their, and their students’, creativity in science. A laudable, but perhaps too lofty, aim which did not survive long. However, I did, and do, believe that the best way to develop students experience in schools is to listen to them and their teachers. This study has only had time to listen to teachers but the message is seems clear to me: worry less about specific teaching techniques and classroom activities and more about the sense of autonomy and confidence teachers experience in authentically collaborative environments if you really want to improve creativity in science lessons. Creativity may be defined in terms of novelty and value but it is understood, by the science teachers in this study at least, in terms of autonomy, optionality, collaboration, confidence, efficacy and excitement. This is a worthwhile, and potentially productive, insight which has justified, to me at least, a few years of study.

Po2 Looking forward

One of the original aims of this study was to find a way to help teachers to encourage and support their own, and their students', creativity in science lessons. It has identified many of the issues that need to be discussed and suggested a possible model of how these factors fit together. I also feel personally better able to think about creativity in the science classroom and explain why it is not simply about posters, video clips, explosions or mind maps. I hope to use this understanding in discussions with teachers in curriculum development projects for some years to come. For this, and the fact that this is the final chapter I will write, I am grateful.

Gareth Price
26 August 2018

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