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A Study of Designerly Activity in Secondary Design and Technology

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Declaration

I certify that this work has not been accepted in substance for any degree, and is not concurrently submitted for any degree other than the Doctorate in Education (EdD) of the University of Greenwich. I also declare that this work is the result of my own investigations except where otherwise stated.

Student D. Trehell (signature)

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Abstract

The purpose of the study reported here was to research designerly activity in secondary design and technology as pupils aged 14 designed but did not make products for the future. Four research questions drove this study: (a) What are the features of the classroom interactions that support pupil's design activity? (b) What sort of designing do pupils do when they design without having to make what they have designed? (c) What is the teachers' attitude to design-without-make? (d) What is the pupils' attitude to design-without-make?

This study is presented in four parts. The first part provides a theoretical positioning by reviewing literature in the following fields:

- *theories of learning which promote the idea that understanding is constructed socially and culturally;*
- *the nature of design activity as revealed by some design professionals;*
- *the nature of design activity as revealed by 'fledgling designers' (Trebell, 2007);*
- *creativity in the context of the design and technology classroom;*
- *literature on classroom interaction.*

The second part describes the research project and methodology in which (a) designerly activity in a secondary design and technology classroom is captured using video data, (b) the work of pupils carrying out the design-without-make unit is scrutinised and (c) the views of the teacher and four of the pupils are obtained through the use of semi-structured interviews. In the third part of the thesis data is presented, analysed and discussed using an analytical framework drawn from the relevant literature (Barlex,

2005; Corden 2001; Coultas, 2007; Hamilton, 2003; John-Steiner 2000; Kumpulainen & Wray 2002; Schaffer, 1996; Schön 1983: 78; Tharp & Gallimore, 1988; Wegeriff & Mercer 2000) supplemented by emergent categories from the data leading to the identification of the following:

- *the range and categories of designing pupils engage in when they design without having to make what they have designed;*
- *the features of the classroom interactions that support pupils' design activity;*
- *the teachers' attitude to design-without-make;*
- *the pupils' attitude is to design-without-make*

The final section comprises the conclusion together with suggestions for further research to build on and extend the findings of the thesis.

Findings indicate that the pupils designing in this context was highly iterative, creative, involved making a wide range of design decisions and revealed understanding of technological concepts. The features of the classroom interactions that support pupil's design activity are many and varied. A number of the features have emerged as themes from the literature and have been tested during this study in order to identify their significance in the development of pupil's designerly activity. These consist of: ***a) Design decisions*** *- Barlex, (2005);* ***b) Learning conversations*** *drawn from literature on constructive dialogue - (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) and* ***c) Scaffolding and Mediation*** *- (Schaffer, 1996; Tharp and Gallimore, 1988).*

It has also been possible to identify a number of emergent categories from the data namely: ***teacher gesticulation,*** *the use of* ***visual stimulus such as laminates;*** *the use of* ***visual stimulus such as film; interactions related to managing pupils' poor behaviour; making use of existing products; making graphics equipment available;*** *showing examples of* ***pupils design work; pupil gesticulation*** *and the* ***teacher exemplifying the generation and development of design ideas.***

In addition findings show that pupils and their teacher valued the experience gained through undertaking a design without make assignment.

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Chapter 1

Introduction

Personal and Professional Context

Prior to becoming a teacher of design and technology nineteen years ago, I trained as a jewellery designer at Art College. This experience enabled me to develop tacit beliefs about 'designerly ways of knowing' (Cross, 1982) and 'designerly ways of thinking' (Lawson, 1997; Lawson, 2006), which have impacted on my approach to enabling pupils to develop 'design capability' (Kimbell and Stables, 2007).

Following a number of Ofsted inspections in which the approaches I had developed were deemed to be highly creative, I became an Advanced Skills Teacher. As an Advanced Skills Teacher, I worked with a large number of teachers, many of whom evidenced little understanding of how to support the development of designerly activity. This personal experience was reinforced by the 2002/03 Ofsted subject report, "Design and technology in secondary schools" (Office for Standards in Education, 2004), which drew attention to the lack of progression in designing skills at a national level. In response to this the KS3 Design and Technology Framework (Department for Education and Skills, 2004) was developed which focussed on the sub-skills of designing.

In 2004, as a centrally based advanced skills teacher working for the advisory service in Kent, I became the county representative for the KS3 Design and Technology Framework. This role required launching the framework to members of over one hundred

secondary schools, followed by a wide range of activities including extensive curriculum development in order to embed sustainable improvement.

It was at this point in 2004, that I joined the EdD programme having become increasingly interested in the synergistic relationship between research and practice. This enabled me to develop a broader understanding of designerly activity informed by research within both the professional and educational design communities. In time, this led to my choice of thesis topic, namely **'A Study of Designerly Activity in Secondary Design and Technology'** with an emphasis on the features of the classroom interactions which support the development of designerly activity in 'fledgling designers' (Trebell, 2007). This topic was chosen as it had the capacity to add significantly to existing knowledge in the field and to inform and influence future practice, both of which are pre-requisites of a doctorate in education.

Previous Work

This thesis builds upon a pilot – 'Design-Without-Make: Challenging the Conventional Approach to Teaching and Learning in a Design and Technology Classroom' (Barlex & Trebell 2007) which was developed in order to test both methodological and analytical assumptions prior to development of the major study. Findings from the earlier study indicated 'that the teacher and pupils responded favourably to design-without-make' (Barlex & Trebell 2007). However, the study indicated that 'it will be important in further work to investigate the nature of the classroom interactions that are required to develop the ability to design well' (Barlex and Trebell, 2007) which is why this thesis focuses in

detail on the features of the classroom interactions which support the development of designerly activity in 'fledgling designers' (Trebell, 2007).

In addition to the publication of the pilot study (Barlex & Trebell 2007), two other papers have been published. The first: 'A Literature Review in Search of an Appropriate Theoretical Perspective to Frame a Study of Designerly Activity in Secondary Design and Technology' (Trebell, 2007) was developed in order to test my understanding of an appropriate theoretical perspective and to share this with the research community in order to enhance my understanding. The second: 'Focussing on Classroom Interaction During Designerly Activity in a Secondary Design and Technology Classroom' (Trebell, 2008) was written in order to share findings from this study relating to the features of the 'learning conversations' (Hamilton, 2003) which facilitate the development of designerly activity in 'fledgling designers' (Trebell, 2007).

Objectives

The aim of this study was to research designerly activity in secondary design and technology where pupils aged 14 designed but did not make products for the future. Four research questions drove this study: (a) What sort of designing do pupils do when they design without having to make what they have designed? (b) What are the features of the classroom interactions that support pupils' design activity? (c) What is the teacher's attitude to design-without-make? (d) What is the pupil's attitude to design-without-make?

Contribution to knowledge

This thesis contributes to knowledge in the field of design and technology as it describes the features of the classroom interactions that support pupils' design activity and deconstructs the nature of the learning that takes place when children design. It also develops the design decisions pentagon (Barlex, 2005), to create a design decisions heptagon (fig 3, p 49) in order to ensure 'inter-rater reliability' defined by Denzin and Lincoln (1994) as 'whether another observer with the same theoretical framework and observing the same phenomena would have interpreted them in the same way' and offers a set of interaction analysis categories for designerly activity (IACDA - fig 25, p 191) which can be used in future studies as a means of both framing the study and interrogating data.

In addition to this, a number of new terms have been created in order to describe more accurately the designerly activity that takes place. These are:

- **'scaffolded sketching'** (Trebell, 2007) - where the act of sketching becomes the centrepiece of designerly conversation with sketching used as a tool to develop a mutually appropriated concept, or as Schön (1983) puts it 'a conversation with the materials of a situation' through the iterative development of the design idea.
- **'fledgling designer'** (Trebell, 2007) – where the term has been developed in order to extend the five levels of expertise (Dorst, 2003), which consist of 'novice', 'beginner', 'competent', 'proficient' and 'expert' to include a category prior to novice, specifically for pupils in schools, who will be designing without having had to

show prior aptitude and proficiency in the field.

- **'think aloud modelling'** – this term has been developed in order to characterise the way in which the teacher modelled designerly activity whilst verbalising what she was thinking, thus making her thought processes explicit.
- **'designerly cultural tools'** – this term has been developed in relation to 'mediated action' (Burke 1969; Wertsch 1985, 1991; Wertsch, Tulviste, & Hagstrom 1993 and Zinchenko 1985) in order to capture the fact that there are a number of distinctly designerly cultural tools which can be either human or symbolic such as 'scaffolded sketching' (Trebell, 2007).
- **'designerly zone of proximal development'** (Trebell, 2007) - when designing collaboratively verbal and visual discourse between individuals, particularly young and mature speakers, is transformed into inner speech and further into designerly thinking and external designerly activity. In this way it is proposed, Vygotskys' theory of the zone of proximal development is built on to create what could be termed as 'the zone of designerly proximal development'

There is a lack of work of this type in the field and therefore this research represents an important contribution which will contribute significantly to the literature in this under-researched area.

Defining Terms

Key terms in this study are **designing**, **making** and **designerly knowledge**. My understanding of the term **designing** is informed by the deconstruction represented in the

KS3 Design and Technology Framework (2004) which views designing as exploring, generating, developing, planning and evaluating ideas throughout the development of a product. A range of modelling techniques will be used throughout this process. These have been usefully defined by Kimbell and Stables (2007) as:

- visual modelling where ideas are progressed through sketching;
- written modelling where ideas are progressed through annotation;
- verbal modelling where ideas are progressed through discussion;
- numerical modelling where ideas are progressed through the use of numerical calculations;
- material modelling where ideas are progressed through the development of three dimensional representations.

Ideas then are central to the concept of designing and these develop and change as a range of modelling processes are employed to inform thinking.

One would think that **making** could be defined as the realisation of ideas using appropriate materials but this study has shown this to be a naïve view. Instead making can manifest itself as 'material modelling' (Kimbell and Stables, 2007) which is undertaken as part of designing in order to progress ideas. It can of course be a means of representing the final idea as a product but interestingly in this study the pupils began to view the idea itself as the product that they had made. Thus I have to conclude that making is a fluid activity which takes place throughout the design process in order to assist the development of ideas.

The concept of **designerly knowledge** has been explored for many years (Cross, 1982; Lawson, 2004) in reaction to the realisation that designers do indeed have a special way of knowing, one which has to be learned by doing. This designerly knowledge leads to the development of a range of precedent (Lawson, 2004) which can be taken and applied to new contexts. It is this kind of knowledge which needs to be developed in 'fledgling designers' (Trebell, 2007) if they are to be able to develop 'design capability' (Kimbell and Stables, 2007).

Issues with Designing within Design and Technology

In recent years Mike Ive (ex HMI subject adviser for design and technology) repeatedly used the term "neat nonsense" to describe the undue time and effort given by many pupils (and teachers) to the presentation of design folios at the expense of content. Parker, (2003:7) echoed this when he gave his personal perspective on the issues based on his experience as both an Office for Standards in Education Inspector and a Local Education Authority advisor:

> *'To a large extent, the tail wags the dog. Teachers are reluctant to change their practices when they have established strategies to ensure their A* to C grades each year. GCSE coursework assessment procedures discourage teachers from breaking the mould. They seem more typically to reward those students who can jump through the assessment hoops rather than encouraging those who are able to show real flare and imagination. The development of creativity in students, the opportunity for them to propose imaginative solutions, take risks, be intuitive, inventive, and innovative in their work, has been sidelined by an approach which has become far too mechanistic'.*

This lack of creativity in the design & technology classroom has been noted by others (Hamilton, 2003; Kimbell, 2000; Spendlove, 2005). The 2002/2003 Ofsted subject report, "Design and technology in secondary schools" (Office for Standards in Education, 2004),

went further by drawing attention to the lack of progression in designing skills. Latterly the importance of creativity has come to feature prominently in the Qualifications and Curriculum Authorities (QCA, 2007) current review of the National Curriculum in England, with creativity being one of four 'Key Concepts' underpinning all subjects, as well as one of the personalised learning and thinking skills outlined in the reforms (QCA, 2007).

Teachers of design and technology in England have been challenged to improve the teaching of the sub-skills of designing through the introduction of the Key Stage 3 Design and Technology Framework (Department for Education and Skills, 2004). One way in which this can be achieved is through the introduction of design-without-make assignments. "Design-without-make" was introduced by Barlex (1999) through the "Young Foresight" initiative, which seeks to develop the skills of communication and collaboration as pupils work in groups to design, (but not make) products for the future. This is a recent design and technology initiative in England which challenges orthodox approaches to teaching design and technology which rely on design and make assignments, focussed practical tasks and product analysis exercises. It challenges pupils to:

1 design but **not** make
2 design products and services for the future
3 use new and emerging technologies in their design proposals
4 write their own design briefs
5 work in groups
6 present their proposals to their peers, teachers, mentors and to adult audiences at innovation conferences.

The research central to this thesis is based on the Young Foresight approach as it advocates the collaborative development of design ideas. This provides an excellent opportunity to research designerly activity as a socially mediated process.

In the view of a number of researchers (Barlex & Trebell, 2007; Hamilton, 2003; Hamilton, 2004; Hennessy & Murphy, 1999; Murphy & Hennessy, 2001; Trebell, 2007; Trebell, 2008), the nature of designing within the design and technology classroom is a social activity drawing on interaction between pupil/pupil and pupil/teacher. Previous studies, (Murphy & Hennessy, 2001) have shown that pupils seek opportunities to interact with peers even when these are not made explicit by the pedagogic stance adopted by the teacher. This view of learning as a socially mediated activity draws on the work of Vygotsky (1978: 90), who believed that:

> *'Learning awakens a variety of internal development processes that are able to operate only when the child is interacting with people in his environment and in cooperation with peers'.*

This study has been framed by and will contribute to socio-cultural theory, drawing heavily on those theories of learning that promote the idea that understanding is constructed socially and culturally (Chaiklin, 2003; Dow, 2003; Hamilton, 2003; Karpov, 2003; Koutsides, 2002; Kozulin, 2003; Lave and Wenger, 1991; Lidz & Gindis, 2003; McMilan, 2004; Miller, 2003; Shepard, 2000; Vygotsky, 1978; Wersch, 1991). Central to these theories is that all higher mental processes are mediated by psychological tools such as language, signs and symbols (Vygotsky, 1978). However, there is a lack of educational research identifying how these tools support design activity in the classroom.

The Structure of the Thesis

This thesis is presented in four parts. The first part will provide a theoretical positioning by reviewing literature in the following fields:

- theories of learning which promote the idea that understanding is constructed socially and culturally;
- the nature of design activity as revealed by some design professionals;
- the nature of design activity as revealed by 'fledgling designers' (Trebell, 2007);
- creativity in the context of the design and technology classroom;
- literature on classroom interaction.

The second part will describe the research undertaken and methodology in which (a) the work of pupils carrying out the design-without-make unit is scrutinised (b) designerly activity in a secondary design and technology classroom is captured using video data, and (c) the views of the teacher and four of the pupils are obtained through the use of semi-structured interviews.

The third part of the thesis will present, analyse and discuss the data using an analytical framework drawn from the relevant literature (Barlex, 2005; Corden 2001; Coultas, 2007; Hamilton, 2003; John-Steiner 2000; Kumpulainen & Wray 2002; Schaffer, 1996; Schön 1983; Tharp & Gallimore, 1988; Wegeriff & Mercer 2000) supplemented by emergent categories from the data leading to the identification of the following:

- the range and categories of designing pupils engage in when they design without having to make what they have designed;
- the features of the classroom interactions that support pupils' design activity;
- the teacher's attitude to design-without-make;
- the pupil's attitude is to design-without-make.

The final section comprises the conclusion together with suggestions for further research to build on and extend the findings of the thesis.

Chapter 2

A Review of Literature to Inform a Study of Designerly Activity in a Secondary Design and Technology Classroom

Theories of learning that promote the idea that understanding is constructed socially and culturally

Previous studies of designerly activity (Murphy & Hennessy, 2001) have shown that pupils seek opportunities to interact with peers when engaged in learning activity even when these opportunities are not made explicit by the pedagogic stance adopted by the teacher. In the view of a number of researchers (Barlex & Trebell, 2007; Hamilton, 2003; Hamilton, 2004; Hennessy & Murphy, 1999; Murphy & Hennessy, 2001; Trebell, 2007; Trebell, 2008), the process of designing within the design and technology classroom is a social activity drawing on interaction between pupil/pupil and pupil/teacher. This view of learning as a socially mediated activity draws on the work of Vygotsky (1978), who believed that through the co-construction of knowledge pupils achieve more than when working alone. John-Steiner (2000:40), clarifies this point further by explaining that in partnerships as in the case of collaborative designing, 'we broaden, refine, change, and rediscover our individual possibilities'. Generative ideas emerge from joint thinking and significant conversations, as in those which take place when the pedagogic stance of the teacher supports collaborative enquiry with the interdependence of thinking leading to the co-construction of knowledge.

This view of learning as a socially mediated process is derived from socio-cultural theory with its focus on human action (Leont'ev, 1959, 1975, 1981; Vygotsky, 1978, 1987) and mediation (Vygotsky, 1978, 1987; Wertsch, 1991; Zinchenko, 1985). The foundations of understanding the various interpretations of the concept of action, can be found in the work of: Bakhtin (1986; see Voloshinov, 1973), with his focus on the 'utterance' as a form of action; Vygotsky (1978, 1987), with his emphasis on speech, thinking, and, more generally, 'mediated action' (Wersch, 1985, 1991; Zinchenko, 1985); and Leont'ev (1975, 1981), with his theory of activity. In the West one can find relevant accounts of action in the writings of Bourdieu (1977), with his description of 'habitus'; Burke (1962, 1966), with his account of 'action' (including symbolic action) and the motives that shape it; de Certeau (1984), with his focus on 'practice and resistance'; Dewey (1938), with his analysis of 'inquiry' as a form of 'human conduct'; Habermas (1984), with his studies of 'communicative action'; MacIntyre (1984), with his analysis of 'intelligent action'; and Mead (1938), with his philosophy of 'the act'.

My purpose in outlining just some of the contributions to the field of mediation and action is to illustrate the range of theory from which my chosen position is derived. As you can see the range of interpretation given to human mediation and action is diverse. Therefore, it is important to ensure that the theoretical underpinning for this study is drawn from an appropriate perspective which enables the study to be framed effectively. This has been achieved by focussing on 'mediated action' (Burke 1969; Wertsch 1985, 1991; Wertsch, Tulviste, & Hagstrom 1993 and Zinchenko 1985).

Burke (1969); Wertsch (1985, 1991); Wertsch, Tulviste, & Hagstrom (1993) and Zinchenko (1985) argue that 'mediated action' where mediation is best thought of as a process involving the potential of cultural tools (or in this case designerly cultural tools) which for Vygotsky (1978; 1981; 1986) involved two faces of mediation, one human, the other symbolic, some primitive such as fingers on which to count and others higher order symbolic mediators including writing, formulae and graphic organisers, is the appropriate unit of analysis for a Vygotskian derived socio-cultural approach.

According to Vygotsky (1978; 1981; 1986), all specifically human mental processes (so-called higher mental processes) are mediated by psychological tools such as language, signs, symbols. Like material tools, psychological tools are artificial formations. For instance, when designing collaboratively, verbal and visual discourse between individuals particularly between inexperienced and experienced speakers, is transformed initially into inner speech. It is then transformed further into designerly thinking relating to the problem to be solved and external designerly activity such as sketching thus utilising (based on Vygotsky's notion of the zone of proximal development 1978, 1981, 1986), what could be termed '*the zone of designerly proximal development*' (Trebell, 2007) in support of the development of the pupils' designerly ability. Vygotsky's 'zone of proximal development' can be achieved in a number of ways including the use of pupil/pupil and pupil/teacher interaction where one of the partners in the collaboration has more knowledge/experience than the other and as such is able to stretch their partner through interactive dialogue. In my view young designers 'appropriate socially elaborated symbol systems' (Vygotsky, 1978). In a designerly context this would include 'relevant

dialogue' (Hamilton, 2007) and the use of 'scaffolded sketching' (Trebell, 2007) where the act of sketching becomes the centrepiece of designerly conversation with sketching used as a tool to develop a mutually appropriated concept, or as Schön (1983: 78) puts it 'a conversation with the materials of a situation' through the co-constructed iterative development of the design idea.

Vygotsky (1986) believed that if one deconstructs a higher mental function into its constituent parts, one finds nothing but the natural lower skills. This is justification in itself for adopting a Vygotskian approach where pupil/pupil pupil/teacher interactions will be studied in depth as these interactions once deconstructed have the power to inform us of the stepping stones that can be put in place to develop designerly thinking and successful designerly activity in a secondary school context.

There are a wide range of different forms of adult mediation, from the adult's presence, which provides the child with a secure learning environment, to encouragement, challenge and feedback (Schaffer, 1996). Tharpe and Gillimore (1988) wrote about such forms of teacher mediation as modelling, contingency management (praise and critique), feedback, and on the other level, cognitive structuring. Rogoff (1995) distinguished three strata of mediation: apprenticeship where newcomers to a community of practice advance their skill and understanding through participation with others (Bruner, 1983; Dewey, 1916; Goody, 1989; John-Steiner, 1985; Lave & Wenger, 1991; Rogoff, 1990), guided participation which focuses on the mutual involvement of individuals and their social partners (Rogoff, 1990; Rogoff & Gardner, 1984); and appropriation, the process by

which individuals transform their understanding of, and responsibility for activities through their own participation (Rogoff, 1990) which enables learning to develop from interpersonal to intrapersonal.

Conclusion

The focus of this section is on the theoretical underpinning of the study. However, the following sections will broaden the theoretical framework by establishing the following:

- a wider range of data collection methods drawn from theories related to the nature of designing both by pupils and professionals (Barlex, 2004; Cross, 1989; Dorst, 2003; Ericsson and Simon, 1993; Ericsson, 2001; Lawson, 2004; Welch, 2000)

- classroom interaction analysis categories will be drawn from the literature on classroom interaction (Corden, 2001; Coultas, 2007; Kumpulainen & Wray, 2002; Mercer, 1995 and Wegeriff & Mercer, 2000) both in the broadest sense and in studies specifically focussing on Design and Technology (Barlex and Welch 2007; Hamilton 2003; Hamilton 2004; Hamilton 2007; Hennessy & Murphy 1999; Murphy & Hennessy, 2001; Trebell, 2008).

The thesis will examine how these theories compliment socio-cultural theories and how they can be used side by side to frame the study of designerly activity in secondary design and technology.

Literature on Design

The nature of design activity

Design of the kind undertaken by professional designers could be considered one of the most intellectually demanding types of thinking as it involves both procedural knowledge, that is knowing how to do something, and declarative knowledge that is factual or conceptual knowledge (Lawson, 2004). In addition designers are required to understand a broad range of contexts and to be able to respond to problems in a creative manner. Cross (1982), coined the phrase 'a designerly way of knowing', in reaction to the realisation that designers do indeed have a special way of knowing, one which has to be learned by doing. Designing in a professional context can be considered as an experiential process mediated by social interaction often in a collaborative environment. Rarely is this the case in the secondary design and technology classroom where individualised learning driven by didactic delivery, is often the favoured mode of instruction.

This section explores how the nature of design activity as revealed by design professionals, can be used to deepen understanding and inform methodological and analytical assumptions during a study of designerly activity in secondary design and technology.

The Design Process

Research into standardised design procedures has led many (Archer, 1984; Cross, 1989; French, 1971; Lawson, 1978; Markus, 1969; Maver, 1970; Pahl and Beitz, 1988 and

Pugh and Morley, 1988) to question the validity of algorithmic versions of a so called 'design process', many of which omit the vital feedback loop which occurs during mental iteration. Mental iteration (Jin & Chusilp, 2006) is seen as a repetition of cognitive activities occurring in designers' thinking processes. In other words as a designer develops their ideas they revisit previous concepts and build upon them in order to develop new insights. This has led some including myself to conclude that the concept of a design process is a misnomer which becomes a straight jacket of conformity inhibiting the designers' creativity (Atkinson, 2002; Barlex, 2003; Davies, 1999; Kimbell, 2002; McLellan & Nicholl, 2008; Rutland, 2002; Spendlove, 2003; Trebell, 2008) by overlooking the heuristic nature of designing at the conceptual stage (Lawson, 2004).

Creativity in the Design Process

Creativity in the design process (Darke, 1979; Kimbell et al, 1991; Dorst and Cross, 2001) is often characterised by the occurrence of a significant event – the so called 'creative leap'. When researching designers and designing, many researchers have conducted 'think-aloud' protocol studies (Ericsson & Simon, 1993; Van Someren et al, 1994) where designers were asked to think aloud as they solved design problems thus giving the researcher an insight into inner thought processes. Despite the think aloud method being widely used in design research, the process runs the risk of inhibiting 'fledgling designers' (Trebell, 2007) as evidenced through the work of Anglim (2006), who used this technique to probe the thinking of a group of sixth form students. This may well be because fledgling designers are still developing conceptual tools and lack confidence when translating their thinking into words. It may also be that the process is

counter-intuitive as different individuals favour alternative modes of cognition (John-Steiner, 2000). Further, it should be born in mind that language is the social representation of thought but does not necessarily mirror thought processes in detail (Vygosky, 1986), so that think aloud experiments are likely to be a poor representation of internal cognition and therefore not the most effective method to meet the stated aim.

Conceptual Design, Ideation and the Prevalence/Relevance of Sketching

According to Cross, (1994); Guilford, (1970); Pugh, (1991) and Roozenburg & Eekels, (1995) conceptual design should contain two kinds of steps: divergent in which alternative concepts are generated, and convergent in which these are evaluated and selected. Ideation (Jonson, 2005), an important element of conceptual design, can be seen as the generation, development and communication of ideas, where the 'idea' is understood as a basic element of thought that can be either visual, concrete or abstract. As such it is an essential part of the design process, in education and professional practice. In this process, freehand sketching has traditionally been considered a core conceptual tool (Bilda & Demirkan, 2003; Cross, 1999; Garner, 1992; Goel, 1995; Plimmer & Apperley, 2002; Schön, 1983; Suwa & Tversky, 1997; Tversky, 1999). Suwa and Tversky (1997) argue that 'designers attend to the very figural or formal properties of sketches as they make them and from this tend to 'read off' new ideas' or as Schön (1983: 78) explains 'designers have a conversation with the materials of the situation' through the generation and development of design ideas.

Bilda et al, (2006) and Jonson (2005) challenged the supremacy of sketching during design activity. Bilda et al (2006) encouraged architects to design without the use of sketching, by visualising the concept and articulating it verbally as part of a 'think aloud' protocol analysis. Jonson (2005) encouraged a number of students and professional designers to develop the notion of 'reflective practice' (Schön, 1983) by self reporting the nature of design tools used during the ideation phase of a given task. Tools recorded included sketching, words, sketch modelling and computing. Findings indicate that designers were not solely dependent on sketching as a means of generating, developing and communicating design ideas. Those deprived of sketching still managed to articulate their ideas effectively but it was acknowledged by Bilda et al (2006) that this was because the participants were experts in their field. As such they would have internalised external tools thus creating highly developed psychological tools (Vygotsky; 1978; 1981; 1986) which were called upon in this instance to support ideation. Bilda et al (2006) acknowledged that when interviewed, the architects stated clearly that they preferred to be able to use sketching as an aid to cognition and that being denied the opportunity to do so was frustrating because their mental processing functions were overloaded.

Design as a Socially Mediated Process

Increasingly studies of designerly activity in a professional context have focussed on social interaction as a key feature of designerly activity (Cross, 1996; Cross et al, 1996; Lawson, 1997 and Medway and Andrews, 1992). Taking place as they do in the naturalistic setting of the design studio, these studies have enabled researchers to analyse the place of language in the development of ideas and to conclude that the spoken word

can act as an essential catalyst in the development of creative outcomes (Cross, 1996; Lawson, 2004).

Novice (students) and Expert Designers

There has been much research effort (Ahmed et al, 2003; Cross et al, 1998; Cross et al, 1994; Dorst, 2003; Ericsson et al 1993; Ericsson, 1999; Ericsson, 2001; Ho, 2001; Kavakli & Gero, 2002) put into attempting to understand the differences between the working practices of novice and expert designers. Interestingly the term 'novice designer' in these papers refers to students or newly qualified designers. There is a distinct lack of research focussing on the pupil as designer which is why this study has the potential to make a significant contribution to knowledge.

The studies on expertise highlighted that the working practices of novice and expert designers vary considerably with 'novice behaviour usually associated with a 'depth-first' approach to problem solving, that is, sequentially identifying and exploring sub-solutions in depth, whereas the strategies of experts are usually regarded as being predominantly top-down and breadth-first approaches' (Cross, 2004). Dorst (2003) identified five levels of expertise. He refers to these levels as 'novice', 'beginner', 'competent', 'proficient' and 'expert'. According to Dorst (2003) the novice tends to follow strict rules, which suggests that they are functioning in a procedural manner. The beginner is more sensitive to the situational context and more aware of exceptions to rules. The competent problem solver works in a different way being selective as to which problem features to attend to and having much clearer ways of working. At this level more learning and reflection is

evident as designers show their willingness to turn to trial and error as a legitimate mode of designerly activity. The proficient problem solver is able to recognize important features with ease and to act upon these with confidence. The expert recognises the nature of the situation intuitively and performs appropriate actions without the need for conscious mental effort.

What it means for pupils to design

This following section explores how the nature of design activity as revealed by pupils (Barlex, 1999; Hamilton 2003; Hamilton, 2004; Hamilton 2007; Trebell, 2008), can be used to deepen understanding and inform analytical assumptions during a study of designerly activity.

Design Activity as revealed by pupils

In moving the design activity from the arena of the professional into the classroom, it is important to develop a description of the activity that reveals how this might be carried out by pupils. Barlex & Welch (2007) have developed a five domain model and justified it by stating that "Conceiving ... what does not exist" (Buchanan 1996: 17) and "developing and designing a novel ... system" (Ropohl 1997: 69) indicate that pupils will, on occasion, need to make **conceptual design decisions**. "Developing and designing a ... technical system" (Ropohl 1997: 69) indicates that pupils will need to make decisions about the way their design will work, that is, **technical design decisions**. "Spatial and temporal details which cannot yet be observed" (Ropohl 1997: 69) indicates that pupils will need to make decisions about the appearance of their designs that is

aesthetic decisions. "...created by the ... manufacturing process" (Ropohl 1997: 69) indicates that pupils will need to consider how they will make their design that is **constructional decisions**. Product designers have commented on how important it is to consider the user when developing design proposals. For example, Jonathan Ive, the designer of the ipod states, "the design of an object defines its meaning and ultimate utility, the nature of the connection between technology and people is determined by the designer" (QCA, 1999: 14). This indicates that some of the decisions made by pupils should be informed by a consideration of the user. These considerations will be broader than any one group of users so such considerations are perhaps better described as **market considerations** which indicates that pupils will need to make decisions related to the market for their product.

Decisions in these five domains (conceptual, technical, aesthetic, constructional and marketing) are not made independently of one another, for as Buchanan (1996: 16) states, "the activity is complex [and] a designer must attend simultaneously to many levels of detail and make numerous decisions as he or she designs". Hence, Barlex (2005) has proposed that these areas of design decision can be represented visually, with each type of design decision at a corner of a pentagon and each corner connected to every other corner. This is shown in Figure 1 with each type of decision at a corner of a pentagon and each corner connected to every other corner.

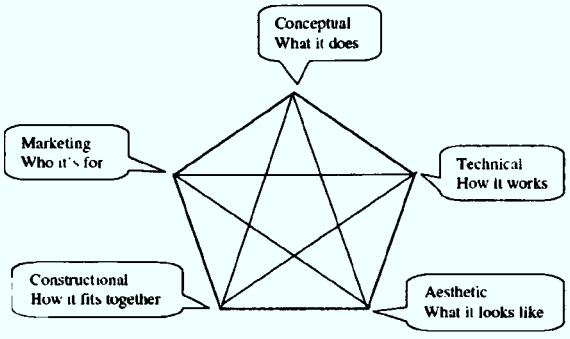

Figure 1 The design decision pentagon (Barlex 2005)

This inter-connectedness is an important feature of making design decisions. A change of decision within one area will affect some if not all of the design decisions made within the other areas. For example, a change in the way a design is to work will almost certainly affect what the design looks like and how it is constructed. It may also have far-reaching effects in changing some of the purposes that the design can meet and who might be able to use it. One can envisage a pupil making a series of "What if I did this" moves (Schön, 1987) as he or she considers possible decisions about a feature and its effects on decisions made or yet to be made about other features. This inter-connectedness reflects a constructivist 'reflection-in-action' paradigm for the pupil, considering the process of designing as a reflective conversation with the situation (Dorst & Dijkhuis, 1995). The use of "What if I did this" process, is more than a mere *ad hoc* tool to cope with the complexity. Its repeated use also increases the designer's understanding of the issues, thereby informing, guiding and stimulating further designing both within and outside the given design situation (Schön & Wiggins, 1992). It is, in

effect, a powerful learning tool that the designer uses to learn about the design proposal as he or she is creating it (Sim & Duffy, 2004).

The design decisions pentagon has been used as an analytical tool by a number of researchers studying designerly activity in the field of Design and Technology education (Barlex, 2007; Owen-Jackson & Steeg, 2007; Rutland and Barlex, 2006; Steeg, 2007a; Steeg, 2007b; Welch, 2007). Findings of these studies have shown that all too often pupils are not given opportunities to make a wide range of design decisions as teachers insist on setting tightly defined design briefs with clearly defined outcomes.

Conclusion

Having reviewed a breadth of literature in the field of designing it is possible to identify methods appropriate for data collection in the proposed study. Bryan Lawson (2004), cites five methods of uncovering design knowledge as the means of finding out how designers are thinking: a) considering the information designers are given and the information they produce, b) observing the designer operating under a controlled situation, c) observing the designer operating in the 'natural' surroundings of their studios, d) asking designers about what they do gaining responses in either writing or by means of interview and e) attempting to model the cognitive behaviour of designers by means of software.

The exploration of what it means for pupils to design has led me to conclude that flatwork, produced as a result of the study, can be analysed by means of the design decisions (fig. 1) that pupils make in order to generate and develop their design idea.

These should include (a) conceptual (b) marketing (c) technical and (d) aesthetic. I will not analyse constructional decisions as the pupils are not required to make the product they design and as such cannot be expected to make constructional design decisions. However, although some justification for the model has been provided it will be important to ensure that it enables 'inter-rater reliability' (Denzin and Lincoln, 1994) so that findings from the study can be considered reliable.

Creativity in the Design and Technology Classroom

An exploration of creativity in the context of the design and technology classroom (Dineen & Collins, 2004; Haffenden, 2004; Hamilton, 2003; Hardy, 2004; Kimbell, 2000; Kotob, Nicholl & McLellan, 2008; McLellan & Nicholl, 2008; Nicholl, 2004; Nicholl, McLellan & Thomas, 2008; Rutland, 2004, and Spendlove, 2005; Steeg, 2007) is critical, in order to deepen understanding and inform methodological and analytical assumptions during this study of designerly activity.

Creativity in Crisis

The National Advisory Committee on Creative and Cultural Education (NACCCE, 1999) report 'All our Futures' stated the importance of creativity in education. Within design and technology, the response to the NACCCE report is exemplified through an increasing debate on creativity from organisations including the Qualification Curriculum Authority (QCA), Design and Technology Association (DATA), Creative Partnerships, The Nuffield Foundation, Technology Enhancement Programme (TEP) and the Young Foresight project.

This interest has been developed further through continued academic interest within the Design and Technology community (Atkinson, 2002; Barlex, 2003; Benson, 2004; Davies, 1999; Hopper, 1998; Howe, 2001; Kimbell, 2002; Kotob, Nicholl & McLellan, 2008; McLellan & Nicholl, 2008; Nicholl, McLellan & Thomas, 2008; Rutland, 2002; Spendlove, 2003; Spendlove, 2004; Steeg, 2007) with an emerging theme of 'creativity in crisis' (Barlex, 2003; Kimbell, 2000) where a paradox appears to exist between the rhetoric of the potential for creativity in Design and Technology and the reality of classroom practice. This is summed up by comments from Parker (2003:7), a senior curriculum adviser for Design and Technology who states that:

> *'Teaching of 'the design process' leads to a fragmented and disjointed approach in which exploration of materials to inform designing is absent and useful procedures are not utilised. The range of teaching and learning styles employed is limited leading to a situation where students are compliant rather that enthusiastic'.*

When reviewing the literature in the field of creativity within the Design and Technology curriculum it would appear that the contributors (Dineen & Collins, 2004; Haffenden, 2004; Hamilton, 2003; Hardy, 2004; Kimbell, 2000; Nicholl, 2004; Rutland, 2004, and Spendlove, 2005; Steeg, 2007) have been influenced by Amobile's (1996) model of the development of the individuals' creativity in the form of the three features model focussing on teacher, learner and task which has been used as an analytical tool in numerous creativity studies in the field.

The Role of the Teacher in providing the potential for creativity in the Design and Technology Classroom

There is a corpus of research evidence which indicates that a substantial amount of pedagogy in design and technology education is prescriptive, controlled and not conducive to the development of creativity (Barlex, 2003; Dakers & Doherty, 2003; Harlen & Holroyd, 1996; Kimbell & Perry, 2001; Peters 2002).

A number of studies including Balchin (2005), Barlex (2000), Creativity in Education, 2003; Cropley (2001), Cummings, 2003; Dineen & Collins, (2004), Dow (2004), Davies (2002), Hardy (2004), Nicholl (2004) and Rutland (2004) have highlighted the importance of the teachers' role in the development of creativity within the design and technology curriculum citing pedagogic stance and confidence as key drivers in pupils' creative development (Davies, 2002; Rutland, 2004 and Murphy 2003). Nicholl et al (2008) in their case study of a designer's working practices, however, highlight the use of two creativity enabling processes namely: 'conceptual combination' and 'analogical thinking' in the generation and development of creative ideas. In conclusion they argue that teachers should understand these and other creativity enabling processes and how to utilise them in the classroom if they are to support the creative development of pupils. This is an important point which invites teachers to understand the cognitive processes at work when pupils are designing and the need to plan learning episodes which support the development of creativity.

The research shows that there are other key influences which include the availability of appropriate resources (Balchin, 2005; Rutland, 2004), the use of a range of teaching strategies (Hardy, 2005), a balance of aesthetic, technical and constructional criteria to support pupils designerly thinking (Rutland, 2004) and extensive use of open questions (Hardy, 2005).

The Learner

Balchin (2005) , Dow (2004), Dineen and Collins (2004) and Hardy (2005) drawing on literature based on socio-cultural theories of creativity stress that it is the importance of culture and environment in encouraging the prerequisite development of interest and commitment in the domain stressing that motivation, the amount of time devoted to a design or problem, perseverance in the face of difficulty, the ability to take risks and independent thought that are the necessary correlates of creativity.

The Task

Balchin (2005); Dineen & Collins (2005); Rutland (2004) and Hardy (2004) drawing on the findings of their extensive naturalist studies believe that planning related to the nature of the brief is vital. In particular they argue that the planning should encourage a heuristic approach where there is no route map and experimentation is both valued and encouraged. In addition to this the structure of the unit (Rutland, 2004) and enabling opportunities to make links with other subjects (Balchin, 2005) are important considerations. This view is supported by others including myself (Barlex and Trebell, 2007; Kimbell and Stables, 2007) who believe that pupils should be allowed to identify

their own problems in order to increase engagement and enable the development of creative outcomes. This view is supported by McLellan and Nicholl (2008) who have also highlighted the importance of classroom climate in fostering student creativity in design and technology. Findings from the McLellan and Nicholl (2008) study were derived from interviews with fourteen teachers across six schools in the preliminary phase; interviews with 126 students across six schools also in the preliminary phase; sixty nine teacher surveys across eleven schools in the intervention phase, and four thousand nine hundred and ninety six student surveys across eleven schools in the intervention phase. The data was analysed using Ekvell (1996) and Isaksen's (2001) nine dimensional model of climate which includes challenge, freedom, trust/openness, idea time, playfulness/humour, risk taking, idea support, debate and conflict. Although all of these dimensions were identified in the data, only challenge and freedom were reported on in the paper, with findings showing that tasks often lacked challenge and pupils were denied freedom of choice, both factors which prevented them from being creative.

Some other considerations

On reviewing some of the findings of an ongoing research and intervention project 'Subject Leadership in Creativity in Design and Technology', Kotab, Nicholl and McLellan (2008) interviewed six technicians and six creative coordinators from participating schools in order to establish ways in which barriers to creativity put in place by the technician could be overcome. Findings suggest that important factors were the need to redefine the technician's role, support this process and to highlight the technician's role in encouraging or hindering a creative climate.

Conclusion

This review of the literature of creativity related to the Design and Technology classroom has led me to conclude that any study of designerly activity must be designed in such a way as to facilitate the creative expression of the pupils. To this end the teacher taking part in the study will be chosen specifically because of her pedagogic stance which supports creative development (Murphy, 2003; Rutland, 2004). The study will focus on the designerly activity which takes place when pupils are working on the Young Foresight Project (Barlex, 1999) designing products for the future using smart and modern materials in answer to a design problem identified by the pupils, thus ensuring learner engagement and the development of intrinsic motivation. It is hypothesized that by providing these pre-conditions for creativity, pupils will be able to engage in effective designerly activity.

Defining classroom interaction

Classroom interaction provides a rich source of data that can be approached and studied from a range of perspectives. Research into classroom interaction developed in the 1950s and 60s and reached prevalence with the work of Flanders (1970). This early work focussed primarily on whole class interaction and led to the development of Flanders' Interaction Analysis Categories (FIAC), a system of classroom interaction analysis which focuses on the role of the teacher orchestrating the learning process of a whole class through teacher/pupil interaction with few categories dedicated to pupil related interactions. The categories within the FIAC system are as follows:

1. **Accepts feelings** - accepts and clarifies the feeling/tone of the pupils in a non threatening manner. Feelings may be positive or negative. Predicting and recalling feelings are included;
2. **Praises or encourages**: praises or encourages student action or behaviour. Jokes that release tension, not at the expense of another individual, nodding head or saying 'uh huh?' or 'go on' are included;
3. **Accepts or uses ideas of student**: clarifying, building, or developing ideas or suggestions by a student. As teacher brings more of his own ideas into play, shift to category five;
4. **Asks questions**: asking a question about content or procedure with the intent that a student may answer;
5. **Lectures:** giving facts or opinions about content or procedures; expressing his own ideas; asking rhetorical questions;
6. **Gives directions**: directions, commands, or orders with which a student is expected to comply;
7. **Criticises or justifies authority**: statements, intended to change student behaviour from non-acceptable to acceptable pattern, bawling someone out; stating why the teacher is doing what he is doing, extreme self-reference;
8. **Student talk-responses**: talk by students in response to teacher. Teacher initiates the contact or solicits student statement;
9. **Student talk-initiation**: talk by students which they initiate. If 'calling on' student is only to indicate who may talk next, observer must decide whether student wanted to talk. If he did, use this category;

10. **Silence or confusion**: pauses, short periods of silence and periods of confusion in which communication cannot be understood by the observer.

The FIAC system in its original and modified forms has been used extensively in classroom observation studies (Wragg 1999) over a number of years and is still an excellent starting point for contemporary studies. However, it should be born in mind that the approach taken to classroom analysis in these early days was positivist in nature with interactions logged at regular intervals, for example, every three seconds on a recording sheet. The data was then statistically analysed in order to show patterns of interaction and reported in terms of the percentage of types of interactions rather than a study of the detail of the nature of the interactions, an interpretive approach which I intend to adopt.

In recent years the role of interaction in supporting the development of learning has become very popular with a number of researchers (Edwards, 1993; Lemke, 1990; Mercer, 1995; Wells and Chang-Wells, 1992) carrying out studies in the field which have utilised video and audio recording in order to collect data and then analysed it in order to discover the nature of the interactions in different contexts. Within Design and Technology Barlex and Welch (2007); Hamilton (2003; 2004; 2007); Hennessy & Murphy (1999); Murphy & Hennessy (2001); Trebell (2008) have begun to focus on the study of a social constructivist approach to pedagogy with the quality and nature of classroom interactions assuming an important role. These studies have shown that there is a strong link between the quality of the nature of the interactions and the overall quality of outcomes showing that classroom interaction within the subject is a vital pedagogic tool which teachers need to master. Interestingly much of this work has focussed on

missed opportunities as teachers adopt a didactic approach and fail to utilise classroom interaction as a pedagogic tool.

Like all human endeavours, the process of learning and in this case learning to design can be examined from multiple perspectives. Interactions can be embedded into the process and used as a constructive tool to enable development, or they can be a by-product of a more formal classroom occurring through pupil initiation rather than premeditated pedagogical design (Hennessy & Murphy 1999; Murphy & Hennessy 2001). In the case of this study, knowledge is seen as socially constructed via means of pupil/pupil, pupil/teacher interaction some involving talk functions, others distinctly linked to designerly activity with language seen as a social mode of thinking or 'overt verbalisation' (Vygotsky, 1978; 1981; 1986). Techniques such as scaffolded sketching, where the act of sketching becomes the centrepiece of designerly conversation with sketching used as a tool to develop a mutually appropriated concept, or as Schön (1983: 78) puts it 'a conversation with the materials of a situation' through the iterative development of the design idea represent a distinctly designerly mode of interaction.

The growing interest in classroom interactions and more generally in the processes of learning inherent in social interaction, reflect a theoretical shift in perspective from learning as instruction to learning as the co-construction of knowledge. These studies (Mercer, 2000; Resnick, Levine and Teasley, 1991; Rogoff, 1990) have begun to emphasise the social and cultural nature of human learning. Learning tends to be seen not only as a constructive process that takes place in the mind of the learner but also as a

process of meaning-making and enculturation into social practices (Kumpulainen & Wray, 2002). In all of these studies the classroom interactions observed have been both verbal and non verbal which has necessitated the collection of both video and audio data in order to ensure the creation of a rich picture of the social setting.

In the view of many authors (Corden, 2001; Coultas, 2007; Kumpulainen & Wray, 2002; Mercer, 1995 and Wegeriff & Mercer, 2000) some of the most creative thinking takes place when people are talking together.

Forms of Classroom Interaction

Many categories of classroom interaction have been developed which start with and build upon the work of Flanders (1970). Important for their prevalence, amongst these are the following:

Speculating: where either pupil or teacher wonder about alternative courses of action;

Explaining: where either pupil or teacher explain their thinking;

Elaborating: where the pupil or teacher develop the initial idea by adding other possibilities;

Questioning: as in Flanders interaction analysis categories where questions are asked but in this case by either pupil or teacher;

Challenging: where either the pupil or teacher aim to drawn more from others usually through challenging questions;

Hypothesising: where the pupil or teacher proposes a theory;

Affirming: where the pupil or teacher agrees with the quality of a pupils thinking;

Feedback: where the pupil or teacher offer feedback on ideas;

Evaluating: where the pupil or the teacher share what they think of the ideas;

Reflecting: where the pupil or teacher reflect on the quality of the ideas.

These categories of interaction analysis have been drawn from the work of (Corden, 2001; Coultas, 2007; Kumpulainen & Wray, 2002; Mercer, 1995; Wegeriff & Mercer, 2000) and have been adopted as they enable the analysis of classroom interaction which is not always orchestrated by the teacher.

The pedagogical manifestations of a social constructivist view of education sees the development of activities such as collaborative learning. Such learning situations give students more opportunities to participate, observe, reflect on, and practice socially shared ways of knowing and thinking, and the extended student interactions arising from these environments can be regarded as windows on students' meaning-making and knowledge construction processes (Kumpulainen & Wray, 2002).

Conclusion

The review of literature on classroom interaction has led me to conclude that the study of designerly activity in secondary design and technology needs to be conducted in a natural setting, that is, the classroom, where social interaction is recorded via video and audio recordings and studied alongside the production of pupils' design work, in order to ascertain the features of the classroom interactions that support pupils' design activity and which form the language of design in fledgling designers, that is, pupils in schools. The term 'fledgling designers' (Trebell, 2007) has been developed in order to extend the

five levels of expertise (Dorst, 2003), which consist of 'novice', 'beginner', 'competent', 'proficient' and 'expert' to include a category specifically for pupils in schools, who will be designing without having had to show prior aptitude and proficiency in the field.

It must be acknowledged that the focus of this section is on classroom interaction during designerly activity and that other sections will establish a wider range of data collection methods drawn from theories related to the nature of designing both by pupils and professionals (Barlex, 2004; Cross, 1989; Dorst, 2003; Ericsson and Simon, 1993; Ericsson, 2001; Lawson, 2004 and Welch, 2000). It will also be shown how these theories compliment socio-cultural theories and how they can be used side by side to frame the study of designerly activity in secondary design and technology.

Chapter 3

Research Design

Research Questions and Justification

Four research questions drove this study:

(a) What sort of designing do pupils do when they design without having to make what they have designed?

This question is important because designing at key stage 3 within design and technology is usually limited by the teacher imposing a problem on their pupils which restricts them to pre-defined outcomes as part of a design and make assignment (Haffenden, 2004; Hamilton, 2003; Hardy, 2004; Kimbell, 2000; Nicholl, 2004; Rutland, 2004). In the case of this study pupils will be defining their own problem which should lead to a far wider variety of outcomes and it is hypothesised, a higher quality outcome.

(b) What are the features of the classroom interactions that support pupils' design activity?

This is an important question as it is acknowledged that classroom interaction is vital to the development of effective designerly activity (Barlex & Trebell, 2007; Hamilton, 2003; Hamilton, 2004; Hennessy & Murphy, 1999; Murphy & Hennessy, 2001; Trebell, 2008). However, not enough work has been done to identify the features of the classroom interactions during designerly activity in secondary design and technology.

(c) What is the teachers' attitude is to design-without-make?

This question has been posed because it is essential to find out how the teacher views the pedagogical approach adopted through the 'Design-without-Make' unit, as it is such a challenge to existing methods.

(d) What is the pupils' attitude to design-without-make?

This question is essential as pupils are used to a directed approach to the subject (Kimbell, 2000; Nicholl, 2004; Rutland, 2004) and so it will be important to identify how they react to a different approach.

Research Paradigm

This study will be framed by and contribute to socio-cultural theory, drawing heavily on those theories of learning that promote the idea that understanding is constructed socially and culturally (Chaiklin, 2003; Dow, 2003; Lidz & Gindis, 2003; Hamilton, 2003; Karpov, 2003; Koutsides, 2002; Kozulin, 2003; Lave and Wenger, 1991; McMilan, 2004; Miller, 2003; Shepard, 2000; Vygotsky, 1978; Wersch, 1991).

In this study 'a constructivist paradigm which assumes a relativist ontology (there are multiple realities), a subjectivist epistemology (knower and respondent co-create knowledge and understandings), and a naturalistic (in the world) set of methodological procedures' (Denzin and Lincoln, 2003) has been adopted in order to explore the nature of designerly activity in secondary design and technology. This provides an excellent opportunity to research designerly activity as a socially mediated process.

Methodology

A review of the literature of theories of learning that promote the idea that understanding is constructed socially and culturally (Chaiklin, 2003; Dow, 2003; Hamilton, 2003; Karpov, Y. 2003; Koutsides, 2002; Kozulin, 2003; Lave and Wenger, 1991; Lidz & Gindis 2003; McMilan, 2004; Miller, 2003; Shepard, 2000; Vygotsky, 1978; Wersch, 1991); and, the nature of design activity as revealed by design professionals (Buchanan, 1996; Cross 2002; Dorst & Dijkhuis, 1995; John-Steiner, 2000; Schön, 1987; Schön & Wiggins, 1992; Sim & Duffy, 2004), has led me to conclude that this study of designerly activity needs to be conducted in a natural setting, that is, the classroom, where social interaction can be recorded via video and audio recordings and studied alongside the production of pupils' design work. This approach will enable me to ascertain the features of the classroom interactions that support pupils' design activity and which form the language of design in 'fledgling designers'

This constructivist research was conducted in a design and technology department by running a design-without-make unit of work for all year 9 pupils. The unit of work being studied is based on Young Foresight (Barlex, 1999). Five teachers taught the unit of work to eleven classes but only one class was studied in detail. According to Yin (1989), small sample size (as in this study) is not a barrier to external validity provided that each study is detailed and analysis of data reveals elements of practice relevant to the study at hand.

The Educational Context and Sample

The site of the intervention was the Design and Technology department of a specialist Arts College with 1300 pupils aged 11–18 years. This school was chosen because staff at the school had experience and expertise in collaborative learning. A year 9 class (age 14 years) was chosen as Young Foresight was designed to be taught in year 9. The class of year 9 pupils chosen for this study consisted of 19 pupils, 8 girls and 11 boys. The class was the bottom set in a year group consisting of 11 classes and the pupils had been put in this set on the basis of their expected performance in the standard assessment tests (SATS). They were regarded by their teachers as amongst the least academically able pupils in the year group. A less able group was chosen as the sample in this case, as they represent a contrast to the group chosen for the pilot, and would therefore contribute to testing the robustness of the model.

Purposive Sampling

Purposive sampling (Cohen, Manion, & Morrison, 2003) was used to choose the teacher and pupils. The teacher was chosen based on her prior experience as a product designer and her position as a teaching and learning responsibility point holder (TLR holder) within the department. It was felt this combination of relevant prior experience and a leading role within the department would enable the teacher to engage confidently and competently with the unit of work. Although the design work of all of the pupils in the class was collected, only four pupils were chosen as the focus for the video recording. These four pupils were identified by their teacher as suitable for the purposive sampling and subsequently for participation in semi-structured interviews because although they

were deemed 'less able' as defined by cognitive ability tests (CATs), their teacher indicated that they were reasonably articulate and confident as were the other members of the class and that these pupils would respond positively and sensibly to being at the centre of the study.

The Teaching Sequence Studied

The unit of work took place over a sequence of 18 lessons over 8 weeks in the Spring Term of 2007. During the lessons in weeks 1–4 prior to the design-without-make activity the pupils were introduced to a range of new and emerging technologies by means of one 20 min TV programme (Modern Materials Technology—The future of). They were also introduced to a range of design strategies using the Young Foresight Toolkit. The strategies covered included PIES which encouraged pupils to consider physical, intellectual, emotional and social needs in a variety of contexts and the 4R's of creativity which encourages pupils to collaboratively develop design ideas from a mindmap using the related world, re-expression, revolutionary questions and random links as a means of prompting creative responses. All toolkit activities were undertaken collaboratively in mixed gender groups of three or four pupils. Although pupils worked collaboratively to address the topics, they all recorded answers individually.

The design-without-make activity took place in weeks 4 - 7. During the lessons in week 4 the pupils worked collaboratively in small groups using mindmaps to develop a range of design ideas. In the lessons in weeks 5, 6 and 7 the pupils worked individually to develop

the detail of a particular design idea. During the lessons in week 8 the pupils developed powerpoint presentations of their work and presented these to the rest of the class.

The exact nature of the content of each lesson within the teaching sequence studied is shown below in table 1.

Table 1 An overview of the lessons within the teaching sequence studied

	Week 1		Week 2			Week 3	
	Lesson 1	**Lesson 2**	**Lesson 3**	**Lesson 4**	**Lesson 5**	**Lesson 7**	**Lesson 8**
Completing pre-assignment questionnaires	Introduction to young foresight. Collaborative development of electronic products as a starter.	Toolkit activity – PIES	Reflection on PIES and how it can support the development of design ideas. Introduction to 4Rs of creativity.	Mindmap of carrying devices starting with school bags as part of 4Rs of creativity.	4Rs of creativity	Discussion of electronic products found at home. Watching the YF films on smart and modern materials	Watching the YF films on smart and modern materials

Week 4		Week 5		Week 6		Week 7	Week 8
Lesson 9	**Lesson 10**	**Lesson 13**	**Lesson 14**	**Lesson 15**	**Lesson 16**	**Lesson 17**	**Lesson 18**
Reflecting on and recapping smart and modern materials studied last lesson.	Reflecting on and recapping smart and modern materials studied last lesson. Designing for the future.	Studying designs for the future produced by previous groups. Continuing with own designs.	Designing for the future	Designing for the future	Completing design sheets and starting powerpoint presentations	Completing design sheets and starting powerpoint presentations	Completing presentations and showing these to the group.

Data Gathering

In order to create a rich picture of the context, a range of data collection methods were used in this study: scrutiny of pupil outcomes, videos of classroom interaction during designerly activity and semi-structured interviews with the purposively sampled four pupils and their teacher.

The lessons were videoed throughout the sequence and the data transcribed verbatim and analysed against a range of categories drawn from the literature and a number of emergent categories derived from the data. The design work of the whole class was collected at the end of the sequence and the semi-structured interviews with the teacher and the pupils took place in the week after the sequence had finished. The interviews were tape-recorded and the tapes transcribed verbatim and emergent categories analysed. The data gathering techniques are summarised in Table 2.

Table 2 – Data gathering techniques	**Flatwork**	**Video evidence focussing on purposively sampled four (i, ii, iii, iv)**	**Semi-structured interview with teacher**	**Semi-structured interview with four purposively sampled pupils (1, ii, iii, iv)**
Data set A – Collected whilst pupils generated design ideas	✓	✓		
Data set B – Collected whilst pupils developed design ideas	✓	✓		
Data set C – Collected during the week after the intervention study			✓	
Data set D – Collected during the week after the intervention study				✓

Justification, Representation, Analysis, Validity and Reliability of the Methods Used

Bryan Lawson (2004), cites five methods of uncovering design knowledge as the means of finding out how designers are thinking: a) considering the information designers are given and the information they produce, b) observing the designer operating under a controlled situation, c) observing the designer operating in the 'natural' surroundings of their studios, d) asking designers about what they do gaining responses in either writing or by means of interview and e) attempt to model the cognitive behaviour of designers by means of software. In this study I will use a mix of methods taken from Lawson's survey as it will ensure that I gain an in depth range of data which can be interrogated in order to reveal the features of the classroom interactions which enable the development of designerly activity in fledgling designers.

During the unit data sets A to D were collected.

Data Set A

Data set A consists of flatwork from the whole class and video evidence focusing on four purposively sampled pupils (i, ii, iii, iv) during lessons where pupils generate ideas. This corresponds with Lawson's methods a) and c). The scrutiny of outcomes as a means of gaining insights into designerly activity is well documented as a research method by the professional design research community (Dorst and Cross, 2001; Ericsson & Simon, 1993; Lawson, 2004; Van Someren & Barnard, 1994) and is beginning to emerge as a popular method within the design and technology research community (Barlex & Trebell,

2007; Hamilton, 2003, 2004, 2007; Rutland & Barlex, 2006). As such the scrutiny of pupil outcomes was adopted as an appropriate way of judging the quality of the work produced during this study.

Analysis of the Flatwork Produced by the Whole Class

The work of all eighteen pupils will be analysed and the findings shown in Table 3 in order to ascertain the level of creativity evident by utilising categories drawn from the Robinson (1999) definition of creativity. This will require the study of each piece of work and making judgements about evidence of imaginative thought, purpose, originality (new to the creator) and value in order to establish whether the outcomes could be deemed to be creative. In order to do this in a systematic fashion a data analysis grid will be developed and used when analysing each piece of work. The analysis will be taken further and deeper by outlining evidence of iterative thinking and knowledge of technological concepts and by auditing the work against the design decisions framework developed by Barlex (2005). This audit did not include constructional design decisions, as pupils were not required to consider the making of their design.

Data Set B

Data set B consists of flatwork from the whole class and video evidence focusing on four purposively sampled pupils (i, ii, iii, iv) during lessons where pupils develop their design ideas. This corresponds to methods a) and c). Video and audio recording focussing on a small group of pupils and their teacher was chosen as it would enable in depth analysis of ongoing interaction between pupil/pupil and pupil/teacher which would allow me to

establish a framework of interaction during designerly activity. This approach supports developments in socio-cultural theory particularly the work of Vygosky, (1978; 1981; 1986) where in depth observation and interpretation are used to answer research questions.

Analysis of the Video Evidence

When analysing the video data the features of classroom interaction during designerly activity will be analysed from four perspectives. Three of these were derived from the literature and the fourth consists of emergent categories drawn from the data.
The analytical categories to be used are:-

Those derived from the literature

i) Design decisions - Barlex, (2005) has suggested that in the context of school-based designing, pupils' designing could be described in terms of making five types of interrelated design decisions: (a) conceptual (b) marketing (c) technical (d) aesthetic and (e) constructional. Conceptual decisions are concerned with the overall purpose of the design, that is, what sort of product it will be. Marketing decisions are concerned with, for example, who the design is for, where will it be used and where will it be sold. Technical decisions are concerned with how the design will work. Aesthetic decisions are concerned with what the design will look like. Constructional decisions are concerned with how the design will be put together. This can be represented visually, as shown in Figure 2, with each type of decision at a corner of a pentagon and each corner connected to every other corner.

Therefore the data will be analysed in order to ascertain exactly what sort of design decisions pupils make when designing without having to make what they have designed.

ii) Learning conversations drawn from literature on constructive dialogue - the data will be analysed with a view to ascertaining the features of the 'learning conversations' (Hamilton, 2003) which facilitate the development of designerly activity in pupils. Categories drawn from literature on constructive dialogue which illuminates a number of talk functions that empower learners in their thinking and acting: speculating, explaining, elaborating, questioning, challenging, hypothesising, affirming, feedback, evaluating and reflecting (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) will be utilised.

iii) Scaffolding and Mediation - there are a great number of different forms of adult mediation, from the adult's presence, which provides the child with a secure learning environment, to encouragement, challenge, and feedback (Schaffer, 1996). Tharp and Gallimore, (1988) have defined such forms of teacher mediation as modelling, contingency management (praise and critique, feedback), and on the other level, cognitive structuring.

Emergent Categories

It is essential that any study focussing on classroom interaction during designerly activity utilises categories drawn from the data as well as those derived from the literature, as these will be specific to the nature of the study being undertaken. In the case of this study

the following nine categories emerged: teacher gesticulation, the use of visual stimulus such as laminates, the use of visual stimulus such as film, interactions related to pupils poor behaviour, making use of existing products, making graphics equipment available, showing examples of pupils design work, pupil gesticulation and the teacher exemplifying the generation and development of design ideas.

Data Set C

Data set C consists of a semi-structured interview with the teacher. This corresponds with method d). A semi-structured interview approach (Cohen, Manion and Morrison, 2003) was chosen as this allowed me to ask pre-determined piloted questions but to probe further in order to gain in-depth information. Questions will be used to probe the teachers' perceptions of the pupils' responses to design-without-make, her views of the quality of ideas produced; whether she would recommend design-without-make to other design and technology teachers; whether the ideas produced were creative; whether pupils came to value the ideas as a product in themselves and whether the strategy alienated pupils from the curriculum. The transcription of the teacher's interview is included in the presentation of data.

Analysis of the Teacher Interview

The answers given to each of the questions will be collated and presented in a table in order to facilitate analysis. These answers will then be analysed in order to ascertain the teacher's answers to the questions outlined above.

Data Set D

Data set D consists of interviews with four purposively sampled pupils (i, ii, iii, iv). This corresponds with method d). Piloted questions will be used to probe what pupils thought of design-without-make; what they actually designed; what they thought of their design; whether they would have had to design something simpler if they had to make it; whether they would recommend design-without-make as a way of enhancing designing skills, and whether the unit led to the production of creative ideas. Transcriptions of the interviews are included in appendix 5.

Analysis of the Pupil Interviews

The answers given to each of the questions will be collated and presented in a table in order to facilitate analysis. They will then be analysed in order to ascertain the pupils' answers to the questions outlined above.

Validity

In the case of this study validity was addressed through 'the honesty, depth, richness and scope of the data collected, the participants approached, the extent of triangulation and the objectivity of the researcher' (Cohen, Manion and Morrison, 2003).

This was ensured through the use of a range of data collection methods including scrutiny of pupil outcomes, videos of classroom interaction during designerly activity and semi-structured interviews with the purposively sampled four pupils and their teacher. The data was triangulated through in depth analysis and discussion in order to develop a clear

understanding of the features of the interactions which support the development of designerly activity in 'fledgling designers' (Trebell, 2007) thus ensuring in line with Maxwell (1992) 'descriptive validity' through the production of a factual account, that is not made up, selective or distorted and as such is objectively factual.

Reliability

Reliability within this study was achieved primarily through 'the degree of accuracy and comprehensiveness of coverage' (Bogdan and Biklen, 1992: 48). This was ensured by conducting the study in a natural setting, that is, the classroom, where social interaction was recorded via video and audio recordings and studied alongside the production of pupils' design work throughout the duration of the design-without-make assignment. The exact detail of processes and instruments has been shared in order to enable the study to be replicated over time, over instruments and over groups of respondents. It should be noted that building, as it does on a pilot this study makes use of instruments which have been proven to be reliable over time.

Inter-rater reliability, that is, 'whether another observer with the same theoretical framework and observing the same phenomena would have interpreted them in the same way' (Denzin and Lincoln, 1994) was used when analysing and interpreting data to ensure consistency. This was achieved by ensuring that each analytical tool was tested by the researcher and the teacher and the findings cross referenced in order to show variation in interpretation. Where variation was discovered as in the interpretations relating to the

design decisions pentagon, the tool was developed further in order to more accurately meet needs.

Potential limitations of the study

Focussing as this study does on one teacher, working with one class, there is a danger that the findings of the study could lack transferability. This issue has been addressed by ensuring that the research design and implementation has been fully documented and that findings focus on the nature of the interactions, as well as their specific content.

Ethical considerations

'As social research necessitates obtaining the consent and co-operation of subjects who are to assist in investigations and significant others in the institution,' (Cohen, Manion and Morrison, 2003) I have sought and gained permission for the study from the Headteacher and governors, pupils and teachers directly involved. I have also sought and gained ethical approval from the University of Greenwich. The document completed in pursuit of this approval forms appendix 1.

In accordance with the school's Child Protection Policy informed consent was obtained from all pupils in the class being studied. It was made clear that should any pupil wish to withdraw their consent at a later date there would be no adverse effects on them, it would be seen as their right to do so.

A meeting was held with the purposively sampled four prior to the research commencing

to explain exactly how the research would be conducted. The pupils were invited to give informed consent (BERA, 2004) which they all did, but had this been denied they would not have been used and there would not have been any adverse effects on them. It was vital given that these pupils were the focus of the study that their participation did not make them vulnerable with their peers. The teacher's knowledge of the class and individuals within the class made it relevant for her to choose the pupils who were invited to become the purposively sampled four based on their confidence and ability to articulate effectively.

When interviewing the pupils I gained informed consent from both them and their parents/guardians. In accordance with the school's Child Protection Policy, there was always another adult in the room when I interviewed children and the interviews took place in the familiar setting of the school. Informed consent was gained from the teacher prior to interviewing her.

In this context as I am a teacher at the school I had to be mindful of introducing a power differential and thus bias into the research. This was avoided by studying a class taught by a colleague none of whom I had taught before.

All information gained as part of the study remained confidential and no participant's identity was revealed. Any data, including video and audio tapes and written data has been stored securely in a locked filing cabinet, in accordance with the schools' child protection policy.

The sixth formers who acted as research assistants attended a two hour training session prior to commencing their role in the study. During this training session it was made clear that they were not to interact with the class as this could adversely affect the reliability of the data. Following completion of the filming the sixth formers were debriefed, and their contribution acknowledged.

Chapter 4

Data Presentation, Analysis and Discussion

Four research questions drove this study: (a) What sort of designing do pupils do when they design without having to make what they have designed? (b) What are the features of the classroom interactions that support pupil's design activity? (c) What is the teachers' attitude to design-without-make? (d) What is the pupils' attitude to design-without-make?

In order to answer these questions I will present, analyse and discuss each in turn.

Research Question A

In order to answer the question: **What sort of designing do pupils do when they design without having to make what they have designed?** Flatwork from data sets C and D collected as pupils generated and developed their design ideas will be presented, analysed and discussed. This section is presented in two parts:

i) Images of the 18 pieces of flatwork collected with accompanying commentary;

ii) Analysis of the flatwork.

4.1 Presentation of data

In order to establish the type of designing pupils do when they design without having to make what they have designed, the eighteen pieces of work shown in Figs. 4 - 21 were collected from the class taught by the teacher interviewed.

each piece of work. The analysis was taken further and deeper by outlining evidence of iterative thinking and knowledge of technological concepts and by auditing the work against the design decisions framework developed by Barlex (2005). This audit did not include constructional design decisions, as pupils were not required to consider the making of their design.

Exemplification of the analytical process based on Design 1, (The Intelligent Motion Pram) is shown below and the results of this analysis are shown in Table 3 indicating the extent to which there was evidence for the presence of each feature in the pupils' design work.

Evidence for imaginative thought - The pupil has drawn a clear diagram showing an intelligent pram which utilises sensors to control both environment and motion, for example when it gets cold the pram responds by warming up, when it gets hot the pram responds by cooling down, thus providing the baby with a temperature controlled environment. This clearly demonstrated imaginative thought giving rise to a design concept. Hence this scores 1 in the data analysis grid shown in Table 3.

Evidence for design purpose - The product, a temperature sensitive intelligent pram has a definite purpose. Hence this scores 1 in the data analysis grid shown in Table 3.

Evidence of originality - In the context of this study this is the only design within the class for a temperature and motion sensitive pram and as such it is new to the creator. Hence this scores 1 in the data analysis grid shown in Table 3.

Evidence of value - The product has value as it is an answer to a problem which could enhance the life of the user. Hence this scores 1 in the data analysis grid shown in Table 3.

Evidence of iterative thinking - There is clear evidence of iterative thinking as the pupil develops the design through a number of sketches. Hence this scores 1 in the data analysis grid shown in Table 3.

Evidence of understanding of technological concepts - The pupil has used a wide range of technologies: sensors which respond to changes in temperature and activate climate change within the unit, sensors which respond to the motion of the baby with a soothing rocking motion. Hence this scores 2 in the data analysis grid shown in Table 3.

Evidence of conceptual design decisions - The pupil has clearly developed the concept for the product to respond to the babies needs both in terms of temperature and motion. Hence this scores 2 in the data analysis grid shown in Table 3.

Evidence of technical design decisions - The pupil shows a clear grasp of how the product will work using a range of technologies. Hence this scores 1 in the data analysis grid shown in Table 3.

Evidence of aesthetic design decisions - The pupil has experimented with a range of forms. Hence this scores 1 in the data analysis grid shown in Table 3.

Evidence of marketing design decisions - The pupil has considered appropriate users. Hence this scores 1 in the data analysis grid shown in Table 3.

Table 3 Analysis of pupil outcomes

Pupils Designs	Imaginative Thought – to form an idea	Design Purpose – to have an intention	Originality – produce novel unexpected solutions	Value – adopt solution focussed strategies	Evidence of iterative thinking – to revisit and develop concepts	Evidence of understanding of technological concepts	Conceptual – the sort of product	Technical – how the product will work	Aesthetic – how the product will look	Marketing – considering the user
Design 1 – Intelligent motion pram	1	1	1	1	2	2	1	1	1	1
Design 2 – electric tattoo	1	1	1	2	4	2	1	2	1	3
Design 3 – speedy ball **(PSP)**	1	1	1	1	2	1	1	2	1	1
Design 4 – HelpAracket **(PSP)**	1	1	1	1	3	3	1	3	1	3
Design 5 – Pet helper	1	1	1	1	2	2	1	2	1	1
Design 6 – scan the baby **(PSP)**	1	1	1	1	2	2	1	2	1	1
Design 7 – Voice activated helmet	1	1	1	1	4	4	1	4	1	3
Design 8 – Sensory chewing gum	1	1	1	4	4	4	1	4	3	4

Pupils Designs	Imaginative Thought – to form an idea	Design Purpose – to have an intention	Originality – produce novel unexpected solutions	Value – adopt solution focussed strategies	Evidence of iterative thinking – to revisit and develop concepts	Evidence of understanding of technological concepts	Conceptual – the sort of product	Technical – how the product will work	Aesthetic – how the product will look	Marketing – considering the user
Design 9 – Baby pillow	1	1	1	1	3	2	1	2	1	1
Design 10 – Old people's pillow	1	1	1	1	2	2	1	2	1	1
Design 11 – Intelligent pram	1	1	1	1	2	2	1	2	1	1
Design 12 – sensory horse coat	1	1	1	1	2	1	1	1	1	1
Design 13 – Smarties T short	1	1	1	1	3	1	1	1	1	1
Design 14 – the golf ball finder	1	1	1	1	3	2	1	2	1	1
Design 15 – Sleep tight baby cot **(PSP)**	1	1	1	1	2	1	1	1	1	1
Design 16 – non puncture tyres	1	1	1	1	3	3	1	3	1	2
Design 17 – Coola coat	1	1	1	1	3	3	1	3	1	1
Design 18 – small trousers	1	1	1	1	2	2	1	2	1	1

Key – 1 – Clear evidence available; 2 – Some evidence available; 3 – Little evidence available; 4 – No evidence available

Summary of analysis of pupil outcomes

When analysing pupil outcomes it is interesting to note that the products designed by the class fall into seven categories. First: those that meet the physical needs of the elderly with one pupil designing a product within this category, second: products for pets with two pupils designing products within this category, third: sport related products with three pupils designing products within this category, fourth: those that meet the needs of babies with five pupils designing products within this category, fifth: transport related products with two pupils designing products within this category, sixth: clothing with three pupils designing products within this category and seventh: products which have been classified as other which were designed by two pupils.

Twelve of the eighteen designs are based on the use of sensors, three on the use of conductive material, one on the use of a global positioning system and two on the use of shape memory metal. These outcomes broadly reflect the stimulus gained by the pupils through the Young Foresight materials. The quality and quantity of annotation on most of the sheets is noteworthy, with pupils clearly articulating knowledge acquired during the unit and applying it to their design work. In this study it is interesting to note that of nine designs produced by female members of the class, six of the designs relate to socially sensitive subjects (children, the elderly), two relate to meeting the needs of pets and only one relates to clothing. On the other hand, three of the designs produced by the male students are linked to sport related activities, two are related to transport, two to high tech clothing with embedded technology, one to body adornment and one to sensory food.

Studying each outcome reveals that all eighteen designs show evidence of imaginative thought, every piece of work has been designed with a client or market in mind and has a clearly stated purpose, the ideas in each case are new to the creator and all of the designs have value. Thus I have to conclude that the design work produced in this unit is creative as it scores highly against the Robinson (1999) criteria for creativity.

However, the pupils have gone further by nine out of eighteen showing evidence of iterative thinking through cyclical development on the design sheet and twelve out of eighteen showing understanding of technological concepts as evidenced through annotation.

It is also clear through the use of the design decisions auditing tool, that all of the pupils have made conceptual design decisions, thirteen out of eighteen have made technical design decisions, seventeen out of eighteen pupils have made aesthetic design decisions and fourteen out of eighteen pupils have made marketing design decisions in relation to their design ideas. Evidence of the design decisions is once again revealed by inspection of the annotation made by pupils on their design sheets.

4.3 Discussion

In answering the question: **What sort of designing do pupils do when they work collaboratively to design without having to make what they have designed?** Removal of the requirement to make what has been designed, allows the pupil to conceive ideas for products that are not limited by their personal making skills and the tools, materials and

equipment available in the school. It also enables them to consider applications of new and emerging technologies that are not accessible to schools.

However the pupils are required to justify their design proposal in terms of four features; technical feasibility, being acceptable to the society in which the product will be used, meeting clearly identifiable needs and wants, and the nature of the market into which the product will be sold (Barlex, 2003). The detail with which the pupils describe and justify their proposals indicates that they are products of worth and capable of manufacture albeit not by the pupils. This opportunity to be creative reflects the creativity of the designer in the world outside school where the designer is seldom required to manufacture their design proposal although of course they have to ensure that it can be manufactured. In addition to ensuring 'manufacturability' the designer has to make detailed technical design decisions that ensure that the technology deployed will in fact perform its appropriate function. Often in such cases the designer will call upon existing solutions as the basis for the technical design decision required.

In a broad and balanced design and technology programme, it will of course be essential for pupils to design and make products so that they can be evaluated in use as opposed to considering their feasibility as design proposals. The design-without-make approach is intended to compliment rather than substitute designing and making.

Pupils are required to tackle a complete designing and making assignment as the major part of design and technology assessment in Year 11. It is important to ask if the success

and motivation achieved through designing-without-making in year 9 is counterproductive in that pupils become discouraged when faced with the reality of having to make what they have designed. This appears not to be the case. Young Foresight has anecdotal evidence that abler pupils tackling design-without-make in year 9 are motivated to choose design and technology in year 10 (Baker, 2006) and that those pupils who experience design-without-make in year 9 use the collaborative learning skills they have acquired to good effect in their major assessment (Pearson, 2004).

The assessment for design and technology in year 9 is based on pupil performance in teacher set and assessed designing and making assignments. The design-without-make experience as such is not used to make this assessment however Young Foresight has anecdotal evidence that the experience leads to increased motivation and performance for designing and making (Hayles, 2005). This is in accord with the findings of Hiebert et al. (1999) and the idea of residual learning, that is, learning that takes place collaboratively and at the moment of learning, is difficult to assess as there are several people involved in the learning. However, such learning makes itself manifest in later individual activities when the individual reveals what he or she has learned.

The pupils in this study showed high creativity and strong designing skills when undertaking a design-without-make assignment. It is important to note that they were supported by an able and enthusiastic teacher. Murphy (2003) in reporting on the evaluation of Young Foresight identified three groups of teachers.

First, those teachers whose pedagogy corresponded with that of the Young Foresight Programme, had the most effective implementations evident in the quality and extent of pupils' learning and motivation.

Second, those teachers whose pedagogy overlapped that of the Young Foresight Programme in important respects, in particular sharing a concern for pupils' autonomy and personal decision making, were able through their engagement in the Programme to extend their pedagogy and achieve some very effective lessons and significant learning. Pupils in these teachers' classes were also very enthused and motivated by their experience of the Programme.

Third, those teachers whose pedagogy was at odds with that of the Programme, in particular in seeing the teacher as authoritarian and pupils as passive receivers, struggled to implement the Programme and undermined its aims. In such cases pupils' participation was marginalised and there were few opportunities available for pupils' learning. Pupils were not motivated by the experience.

The teacher in this study belonged to the first group and the pupils clearly benefited from her expertise and pedagogical position. The teacher worked closely with individual pupils using questions to help the pupils develop the detail of their design proposals and resolve emerging issues. She also referred pupils to their previous work in using the Young Foresight Toolkit and the Young Foresight website in order to scaffold their designing.

Design-without-make outcomes

A consideration of the student's design-without-make outcomes reveals the following. First, design-without-make empowers pupils to select their own problem based on personal interest resulting in multiple problems being addressed in one classroom at any one time. It is significant that the teacher did not impose her own design ideas on those of the students. She actively maintained their ownership of the developing design.

Second, there is strong evidence to suggest that pupils generate, develop and communicate design ideas on a single sheet by working iteratively to produce some highly complex solutions. In this study the pupils chose to generate one design idea and then worked iteratively using annotation, collaborative dialogue with the teacher and images to develop the idea further on the same page. As reported earlier, research by a number of individuals has articulated concerns that creativity is under threat because teachers have adopted a linear repetitive approach to the design process which fails to foster creativity (Haffenden, 2004; Hamilton, 2003; Hardy, 2004; Kimbell, 2000; Nicholl, 2004; Rutland, 2004, and Spendlove, 2005). In this case where pupils were given a choice they did not choose a linear but rather a cyclical route through the generation, development and communication of design ideas. This increased freedom enabled them to express themselves more effectively and led to a very high quality of outcomes.

Third, it is clear from the analysis of the design ideas that the pupils are being creative and from their comments that they found the activity highly satisfying. In this study the pupils were able to explain why they liked the design-without-make approach. 'I liked

doing it because it's different to other things that you do, and you can learn more stuff' 'We still got to make a project on it, and had to show it to the class.' Interestingly the pupils' choice of language in the second quote suggests that she sees the design idea, or concept, as a product in itself which is very positive and challenges the prevailing curriculum model where a made artefact is seen as the main outcome of pupils' learning (McLellan & Nicholl, 2008; Trebell, 2008).

An interesting feature of the Young Foresight approach is that it requires pupils to work collaboratively. Murphy and Hennessy (1999) have identified a set of optimal preconditions for collaboration in the design and technology classroom.

There is resonance between their findings (shown in italics) and those of this study. For example:

1. *Teacher commitment to supporting learning through collaboration and understanding of collaboration as a learning mechanism.* This was evident from the behaviour of the teacher in the classroom and her subsequent comments;

2. *School and classroom organisation which supports small groups (including enough time to do so ... and reinforcement of the value of collaboration through evidence of teacher collaboration.* The students interviewed specifically mentioned the usefulness of having sufficient time and the teacher evidenced collaboration in the way she interacted with pupils;

3. *A range of pedagogic strategies supporting collaboration including: knowing how to scaffold student's problem solving through offering both ideas and tools to make student's thinking explicit to themselves and others and monitoring individual understandings as solutions evolve over time and helping students reflect on their*

thinking and the sources of changes in it. The teacher showed great skill in her ability to scaffold without depriving the students of ownership of the task.

Research Question B

What are the features of the classroom interactions that support pupil's design activity? In answering this question video evidence from data sets A and B collected as pupils generate and develop their design ideas will be presented, analysed and discussed.

Presentation of data

4.4 Presentation of Data

The content of the lessons during the duration of the design-without-make assignment is shown summarised in table 4 below.

4.4.1 Table 4 Content of the lessons videoed.

	Week 1		Week 2			Week 3	
	Lesson 1	**Lesson 2**	**Lesson 3**	**Lesson 4**	**Lesson 5**	**Lesson 7**	**Lesson 8**
Completing pre-assignment questionnaires	Introduction to young foresight. Collaborative development of electronic products as a starter.	Toolkit activity – PIES	Reflection on PIES and how it can support the development of design ideas. Introduction to 4Rs of creativity.	Mindmap of carrying devices starting with school bags as part of 4Rs of creativity.	4Rs of creativity	Discussion of electronic products found at home. Watching the YF films on smart and modern materials	Watching the YF films on smart and modern materials

Week 4		Week 5		Week 6		Week 7	Week 8
Lesson 9	**Lesson 10**	**Lesson 13**	**Lesson 14**	**Lesson 15**	**Lesson 16**	**Lesson 17**	**Lesson 18**
Reflecting on and recapping smart and modern materials studied last lesson.	Reflecting on and recapping smart and modern materials studied last lesson. Designing for the future.	Studying designs for the future produced by previous groups. Continuing with own designs.	Designing for the future	Designing for the future	Completing design sheets and starting powerpoint presentations	Completing design sheets and starting powerpoint presentations	Completing presentations and showing these to the group.

In order to ascertain the features of the classroom interactions that support pupil's design activity, video evidence was collected focussing primarily on the designerly activity of four purposively sampled pupils. However, the focussed observations were supplemented by footage of teacher/whole class interaction and of the teacher moving from group to group.

In the first instance, twenty one thirty minute DVDs were analysed in order to ascertain the extent to which the content included designerly activity supported by examples of relevant scaffolding and mediation. Examples of the broad scope initial analysis are shown in Tables 5 and 6 below which represents two thirty minute lessons rich in scaffolding and mediation (lessons 15 and 16) and one which lacks scaffolding and mediation (lesson 8). The rest of the broad scope analysis is contained in appendix 2. The position of the lessons presented in tables 5 and 6 in the overall sequence is highlighted in table 4 above.

The initial analysis of the video discs revealed that of twenty one discs, eleven included designerly activity, the others showed the completion of toolkit activities and the study of films used to develop pupils knowledge and understanding of relevant technological concepts for application to later designerly activity. The remainder focussed on the development of powerpoint presentations to be presented to the rest of the class.

As a result of the initial analysis lessons 3, 4 and 5 where the pupils are working on the four R's of creativity, lessons 9 and 10 where pupils are recapping what they learnt from the films and then applying this to the generation and development of design ideas, lessons 13 and 14 where pupils are continuing to develop their design ideas and lessons 15 and 16 where pupils complete their design ideas, will be studied in depth using fine grained analysis. The position of these lessons within the overall sequence is highlighted in grey in table 7 below.

4.4.4 Table 7 The position of the lessons which will be analysed in detail within the overall sequence

	Week 1		Week 2			Week 3	
	Lesson 1	**Lesson 2**	**Lesson 3**	**Lesson 4**	**Lesson 5**	**Lesson 7**	**Lesson 8**
Completing pre-assignment questionnaires	Introduction to young foresight. Collaborative development of electronic products as a starter.	Toolkit activity – PIES	Reflection on PIES and how it can support the development of design ideas. Introduction to 4Rs of creativity.	Mindmap of carrying devices starting with school bags as part of 4Rs of creativity.	4Rs of creativity	Discussion of electronic products found at home. Watching the YF films on smart and modern materials	Watching the YF films on smart and modern materials

Week 4		Week 5		Week 6		Week 7	Week 8
Lesson 9	**Lesson 10**	**Lesson 13**	**Lesson 14**	**Lesson 15**	**Lesson 16**	**Lesson 17**	**Lesson 18**
Reflecting on and recapping smart and modern materials studied last lesson.	Reflecting on and recapping smart and modern materials studied last lesson. Designing for the future.	Studying designs for the future produced by previous groups. Continuing with own designs.	Designing for the future	Designing for the future	Completing design sheets and starting powerpoint presentations	Completing design sheets and starting powerpoint presentations	Completing presentations and showing these to the group.

In order to interrogate the data further teacher/pupil, pupil/pupil interactions were presented in a grid and analysed to show the nature of the classroom interactions which took place during designerly activity. An example of the data analysis grid is shown in Table 8 below, the rest are available in appendix 3.

				explain all of this. So think about Where might you put things? So you could keep this like this and then put that there. Okay [unclear] you've got to get on there as well. Yeah? No you have to do it for yourself but I can help you. Miss have you got any scissors? What might be nice on yours is if you do the text so that it is circular. Have you got a compass? So are you going to draw your line on? If so do it nice and faintly. Yeh!	[unclear] And that, and that… What, colour that in and then… Yes please. No Alright. That is a good idea.	Pupil A to pupil C – how do those colours look now? Pupil C – Good	to work. Noticeably the pupil with the lowest literacy levels and very short attention span is wondering around distracting others.

which support the development of designerly activity in fledgling designers.

Abstracts showing the fine grained analysis grids, how they were coded for each of the codes and what the coding represents is shown in tables 9a, 9b, 9c and 9d. The rest of the fine grained data analysis grids can be found in appendix 4.

4.5.1 Analysis of Design Decisions

Barlex, (2005) has suggested that in the context of school-based designing, pupils' designing could be described in terms of making five types of interrelated design decisions: (a) conceptual (b) marketing (c) technical (d) aesthetic and (e) constructional. I have extended the original design decisions pentagon by adding two further categories. The first deals with materials, that is, what materials will be used? The second deals with safety, that is, will the product be safe to use? This is now presented as the design decisions heptagon shown earlier in this thesis. In analysing the data, quotes from the transcripts in appendices 4A, B, C and D have been citied in order to clarify the points made. These quotes have been marked in red on the transcripts for ease of reference.

4.5.2 Analysis of Design decisions made by pupils in lessons 3, 4 and 5

When analysing the video data for lessons 3, 4 and 5, transcripts of which are included in appendix 4A it is interesting to note that during the initial part of the lesson when the teacher was getting the pupils to undertake a collaborative mindmap of different types of carrying devices and recap on the meaning and application of PIES, no design decisions were made. This reflects the nature of the interaction which was taking place which did not require pupils to undertake designerly activity. Having moved to the four Rs of creativity, pupils did not make any design decisions when they were watching their teacher model the process. As soon as they were allowed to begin their own work however, design decisions began to be taken and included aesthetic design decisions relating to the shape and form of the product. Technical design decisions were made relating to issues such as how straps would function and in answer to questions such as 'Do you think it would be like, like do you think it will have a big pom pom, or do you think you might sew some of it?' to which the pupil answered 'No just free', decisions related to the materials to be used were exemplified by the teacher asking 'What material do you think that would be made from?' and the pupil responding 'leather', and marketing design decisions related to who the product was for.

During the plenary the pupils were unable to make any design decisions as the time was spent showing what they had produced and explaining how they had developed their ideas from inspiration to the rest of the class.

4.5.3 Analysis of Design decisions made by pupils in lessons 9 and 10

When analysing the video data for lessons 9 and 10, transcripts of which are included in appendix 4B, it is interesting to note that during these lessons the pupils recapped the knowledge gained from watching films about smart and modern materials. Once the films finished they were shown some examples of previous design work completed by pupils working on the Young Foresight unit. The teacher talked about the designs in depth pointing out what made them effective.

As part of the introduction to the designerly activity that the pupils were about to embark upon, the teacher began to produce a mindmap of the type of user groups and products that the pupils might concentrate on by making comments such as 'so, you could be thinking about um, women with children. You could be maybe incorporating something that might help the children into their push chairs'. She went on to say 'you might be thinking about uh people who have got blindness, or people who are deaf, or people who have disabilities, people who can't use their hands'. Through this dialogue she was exemplifying marketing decisions by encouraging the pupils to decide who their product is for. She made her point even clearer by showing the pupils the exemplar design work and making the following comments 'this is for children, this is for blind people, these are um...this is for blind people as well' Having illustrated this, the teacher asked the group to produce a mindmap of possible user groups which she placed on the board. At this point the pupils were standing around the whiteboard whilst the teacher wrote the user groups on the board. Having identified a range of user groups the teacher went on to mindmap products with the group using a range of questioning techniques such as 'think

about maybe where a baby goes to sleep. There are a lot of things with cot deaths. How can maybe something with smart fabric help with cot death? What do babies have in their room when they go to sleep, so that parents can keep an eye on them?' The pupils replied that often infants have baby monitors. The teacher continued 'exactly, so they also have the little speakers, so could that be put into something else? Could it go into the bed somewhere, so that the speaker is actually a lot closer...' This dialogue shows the teacher co-constructing conceptual, technical and safety related design decisions with the group. She goes on to say 'Okay, so you could have something...if you have it in the pillow, what kind of technology could you be using? Is it going to be big and hard, like a speaker? What technology did they use on the DVD?' This encourages the pupils to draw information from the videos that they had seen and apply this in order to begin to make technical and material related design decisions. The teacher continued to model the construction of both technical and conceptual design decisions drawing on prior knowledge in order to challenge the pupils to come up with exciting possibilities.

Having taken part in the collective mindmap the pupils returned to their seats and began to generate their own ideas to solve problems which they had identified. One pupil immediately took the opportunity to share her designerly thinking with the others on her desk by saying 'I might do a TV screen which you put across there (she gesticulates across her stomach) so that you can see the baby on it. Shall I do that?' Through this dialogue she shares her designerly thinking but goes on to seek the approval of her peers. In this one sentence she is beginning to make conceptual, technical and aesthetic design decisions whilst interacting with peers.

At this stage the teacher moves from whole class to one to one interaction, circulating around the class in order to ensure that all are beginning to generate their own ideas. She receives information from pupils and then challenges them with comments such as 'Okay, good. So, it is going to be flexible is it, good! Okay, so you need to explain to me why, why you've got a voice box in here'. This sort of interaction allows pupils to begin to make material, marketing, conceptual, technical, aesthetic, safety and constructional design decisions by constantly challenging their thinking. Interactions both pupil/pupil and pupil/teacher are a very strong feature of the lesson at this point and the nature of these interactions helps ensure that all pupils begin to develop their own designerly thinking some with very little help, others with quite a lot of help.

At the end of the lesson the pupils were asked to present their emerging ideas explaining who they were designing for and what they were designing. This is exemplified in the following 'I am doing a coat for a horse. When it is cold it warms it up. If it is hot it cools it down' This shows that the pupil has already begun to make a number of design decisions, she has identified the type of product thus making conceptual design decisions, she has begun to work out what the product will do by making technical design decisions and she knows that the product is for the owner of a horse thus she has made marketing design decisions. Another pupil was able to give more detailed information when he explained 'I'm doing a T-shirt that has a computer on it, right? And it has a USB cable for the computer, downloads pictures off the computer to put onto a memory disc, put the memory stick into this compartment on the T-shirt and then it goes onto the picture'. In this statement the pupil shows that he has made conceptual, technical, material,

constructional, aesthetic and marketing design decisions and he is able to articulate these effectively to the rest of the class. There are many other examples of the design decisions that pupils made during the session contained in appendix 4B.

4.5.4 Analysis of Design decisions made by pupils in lessons 13 and 14

When analysing the video data for lessons 13 and 14, transcripts of which are included in appendix 4C, it is interesting to note that this lesson began with an exploration of the PIES activity, where pupils were asked what the letters stand for (that is physical, intellectual, emotional and social needs). The teacher then helped the pupils to reflect on the design decisions that they had already taken by asking questions such as 'Who is your market though, can you remember?' The pupil gave his answer and then the teacher clarified this with a comment which made it clear that the pupil had made conceptual, marketing and technical design decisions but that these could be used to support the social needs of the client. This was an interesting way of drawing on prior learning and of making sure that the pupils understand the links between their designerly activity and toolkit activities such as PIES.

Having reflected on the pupils' prior learning the teacher realised that the presentation of the work could be improved. In order to support the pupils in doing this, she got them all to gather around one table and took the time to model a number of graphical techniques which would help them to improve the quality of their work. During this element of the work the teacher chose to contextualise the activity by using one of the pupil's designs as the starting point for her illustration. This enabled ongoing conversation about the nature

of the design decisions to take place which focussed on technical, conceptual and aesthetic design decisions. Having completed the input, the pupils returned to their desks and talked to each other, making comments such as 'I have to draw mine smaller' which showed that the teacher's interaction had affected the way in which the pupils viewed their work and challenged them to make further improvements.

Once again the forms of interaction moved from whole class to pupil/pupil and pupil/teacher with the teacher taking the time to move around the room interacting with all of the pupils in turn in order to challenge their designerly thinking by making comments such as 'So now what are you going to do; You need to explain what all this is and this'; 'OK so you are going to redraw these nice and big'. Having spent time discussing the nature of the designs and the needs that the products meet, the teacher had become very concerned about the presentation of the designerly thinking and interacted with pupils in order to ensure that they presented their work to the highest possible standard. This is interesting as it suggests that having helped pupils generate an idea the teacher is keen for them to develop their thinking ensuring that their technical understanding is sound and the quality of presentation helps them to communicate their ideas to the rest of the class.

It is interesting that once the type of pedagogy moves from whole class instruction to pupil/pupil, pupil/teacher interaction the pupils begin to seek support from each other. One example of this led Pupil A to ask pupils C 'what do you think of the name – Scan the baby?' In response to this pupil C replied, 'good!'

Throughout the main part of the lesson the teacher continued to circulate supporting pupils on a one to one basis. She scaffolded design decisions by asking challenging questions which covered the range of possibilities but interestingly peers took an active role in this process. They also challenged each others' thinking and supported the development of effective design ideas.

At the end of the lesson the teacher brought all of the pupils together around one table with their design ideas. She talked animatedly about the quality of the work that the pupils were producing and referred back to the exemplar work that she had shown at the beginning of the lesson explaining that the current work was as good as if not better than the original pieces with comments such as 'These are just as good as, or some of them are even better than the other sheets that I showed you, right at the beginning of the lesson'. This element of the lesson was purely descriptive explaining some of the design decisions that had been made but not enabling the pupils to make any more.

4.5.5 Analysis of Design decisions made by pupils in lessons 15 and 16

When analysing the video data for lessons 15 and 16, transcripts for which are included in appendix 4D, it is interesting to note that at the start of the lesson the teacher spent some time recapping the sort of information that should be available on the design sheets. She did this by targeting individual pupils with questions such as 'So Maxine, what needs to be on there?' Responses to this sort of questioning made it clear that the pupils knew that they had to share conceptual, technical, marketing and aesthetic design decisions through their design work by explaining, what the product does, how the product works,

who the product is aimed at and what the product will look like. Having finished this discussion the teacher drew the pupils thinking together by showing a design sheet that she had produced in order to exemplify a quality outcome. This having been produced in advance included all of the information on design decisions which the pupils had highlighted as essential thus reinforcing the effectiveness of their whole class interactions. She went on to critique her work by saying 'The picture in the middle is a bit too small, I think, yeah ..... This is not finished obviously, this is taking what we started last week from Martin, so it is my t-shirt at the side, and then I'm putting in boxes all the different areas that I need to look at. So, what is it? How does it work? Who is it aimed at? Why do this T-shirt? Okay? So, you're looking at all these different things. Everything that you've mentioned are the things that I thought you should put on there as well. So, something nice, bright and catchy but something that's well presented' This approach shared the quality of the work and the nature of design decisions that had to be made with the group in a way that they could refer back to for the duration of the lesson as the piece was left on display on the board thus giving the pupils something to aspire to and a clear view of expectations.

Once the class started work on the their own design sheets the teacher continued to support their learning through constant challenge with comments such as 'Good, do not forget to put the boxes on so that you can explain all of this' and 'So think about planning it out. Where might you put things? So you could keep this like this and then put that there'. This shows that the teacher is very concerned about the overall presentation of the pieces and wants pupils to realise the importance of this when ideas are presented to an

audience. Throughout this section the teacher is referring to the conceptual, technical, aesthetic, material and safety related design decisions which pupils have to make and need to articulate to their audience. Interestingly she prompts the pupils' thinking at every opportunity but does not impose her own ideas through comments such as: 'So maybe you can have the bike and then you can have the person with the suit that they wear which has leather which would on impact go harder'. This enables the pupils to develop their design sheets in a way which allows them to retain ownership and pride in their work. Interestingly when the teacher was having this sort of discussion, peers felt that they could contribute with comments such as 'You could have a T-shirt, and trousers and that yeah, and it goes like that into a big bubble when you crash' evidencing the fact that the pupils were happy to work collaboratively in order to scaffold each others' learning by proposing their own thoughts about the ideas being discussed.

At the end of the lesson the teacher once again brought all of the pupils and their work around one table. At this point she suggested through comments such as 'Right. Okay. I think what you can see from all of this is the designs that everybody has taken away from what we were doing on the board' thus reminding the group that all of them had gained some inspiration from the collaborative mindmap which had taken place prior to the generation and development of pupils own design ideas. She also asked the pupils to '.... pick out some bits that you think are working particularly well' on each of the design sheets which encouraged them to study and learn from each others designerly activity. This was very effective and enabled the pupils to draw ideas from each other and to use these in subsequent lessons in order to improve their own work. In each case the teacher

asked individuals to share their thinking by challenging them with questions such as 'Kirsty Why do you like the horse coat one?' to which the pupil replied 'Because it stands out'. The teacher asked several pupils and ensured that all were listening to the answers during this session.

4.5.6 Analysis of Learning Conversations drawn from the literature on constructive dialogue

The data will now be analysed from an alternative perspective with a view to ascertaining the features of the 'learning conversations' (Hamilton, 2003) which facilitate the development of designerly activity in pupils. In certain instances this will necessitate re-examination of elements of the text in order to scrutinise it through a different lens. Categories drawn from literature on constructive dialogue which illuminate a number of talk functions that empower learners in their thinking and acting: speculating, explaining, elaborating, questioning, challenging, hypothesising, affirming, feedback, evaluating and reflecting (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007), will be utilised. Speculating, explaining, elaborating, questioning, affirming and feedback represent language functions that support cognitive processing whereas challenging, hypothesising, evaluating and reflecting, represent cognitive processing. In analysing the data, quotes from the transcripts in appendices 4E, F, G and H have been citied in order to clarify the points made. These quotes have been marked in red on the transcripts for ease of reference.

4.5.7 Analysis of Learning Conversations in lessons 3, 4 and 5

When analysing the video data for lessons 3, 4 and 5, transcripts of which are included in appendix 4E, it is interesting to note that these lessons show a broad range of talk functions taking place. Initially the teacher explains the task and challenges pupils to remember the work that they carried out during the previous lesson. Questioning is utilised extensively at this point to challenge the pupils' thinking, however, when the teacher receives the answers she takes time to affirm the responses before moving onto the next question. This is a typical mode of interaction in the traditional classroom and is known as the Initiation-Response-Feedback mechanism (Brown & Renshaw, 2000).

Having explained that the pupils were going to be working on the four Rs of creativity in order to re-design a carrying device, the teacher used extensive questioning in order to collaboratively mindmap a broad range of carrying devices. The teacher then reflected on responses by saying 'Okay, you've got your school section, because you're school pupils' and elaborated by adding 'that's what you relate to more', she went on to challenge them to 'think about other people's needs' and to affirm and elaborate by saying 'What kind of people need rucksacks?' It is interesting to note the complexity of interaction required to ensure that pupils think beyond the obvious.

The teacher went on to use questioning to challenge the group with comments such as 'think about another type of group of people who it would be very important if they had food on them. What might they be doing? Might...what might they be looking after?' The response to this was 'Children' and led the teacher to ask 'So, what types of people

have children?' As well as questioning here the teacher is challenging and then reflecting on the answers and using this as a starting point for the next challenge. Through this teacher led set of interactions, the teacher is using her knowledge to accept and build upon the pupils thinking which eventually leads to an extensive overview of carrying devices which pupils can refer to during their design work. During these interactions the teacher gives regular feedback and tends to elaborate on pupils' ideas thus allowing them to maintain ownership of the thought but showing them how it can be extended.

During the elaboration process the teacher made good use of designerly knowledge to bring the idea to life and to relate it to pupils everyday knowledge through comments such as 'Um, and this kind of device um, is similar to the ball barrow designed by James Dyson who also did the dual cyclone' This shows that the teacher knows her field and is willing to draw extensively upon this in order to enhance the pupils learning experience.

Once the pupils were asked to copy the mindmap onto their sheet the teacher moved from whole class interaction to one to one interaction. During this phase she used a number of questioning, affirming and challenging strategies in order to ensure that the pupils actually did the task required of them. Despite the fact that the teacher could have left the pupils to get the work done at this point she interjected as ideas came to her for example 'Any of you have a paper round? Any problems with your paper bag? Is there anything you could use to make it better? Do you walk around or bring your bag? Do you have a bag over your shoulder?' This stream of questions served to engage a number of the pupils. They were challenged to reflect on the paper bag that they used and to analyse its

functional qualities. They did this very well and learnt a lot about the different types of carrying devices used by those within the group. During this lively interaction the teacher speculated about issues related to paper bags based on her prior knowledge gained when she had a paper round as a child, she explained the issues which she faced and once the pupils contributed their stories to the discussion she elaborated on the problems which existed. This was typical of the level of interaction that took place between the pupils and their teacher which gave them ownership of the discussion and made it clear that their contributions were highly valued.

Once the pupils had completed the mindmap the teacher explained that they were going to draw their own bag in the space available on the sheet. She elaborated on the explanation by taking one of the pupil's bags and drawing it on the board so that the group could see what was required of them. By doing this she was challenging the group to do their work just as effectively and modelling the ability to reflect as she questioned how well her drawing was progressing. She then moved to one to one interaction giving pupils feedback on their drawing as it progressed. If the pupils had difficulty with their work the teacher would help them with their drawing saying things such as 'That line goes that way, and that line has to go that way, okay? And then you can follow that around'. Through the nature of this interaction the teacher was able to explain how to do the drawing whilst modelling the process, she could speculate as to the effectiveness as the drawing emerged, elaborate on both the drawing and the explanation as it progressed, challenge the pupils to draw effectively and model reflection as the work progressed. When analysed in this way it is clear to see that an interaction which seems relatively

simple is actually very complex, expressing a number of requirements and modelling expectations.

Having allowed the pupils some time to do the first drawing the teacher explained that the class were now going to begin to transform their design using stimulus from the underwater world. In order to model her point she began to develop what she had on the board using laminated images as inspiration. She explained 'Now, this is where your designs will start changing shape', speculated through comments such as 'so, I might look at this one and it's got like a starfish design on it,' and challenged the pupils throughout to pay attention to what she was doing. Throughout this part of the lesson the teacher reflected on the progress being made with her design idea and evaluated its effectiveness. This approach served to model her thought processes so that the pupils could emulate them.

Having modelled the requirements for the second drawing the teacher explained that the pupils could begin this process making use of tracing paper to trace their initial design and transfer it onto the space for the adapted design. She then issued tracing paper and pencils and allowed the pupils to get on with the work. However, when it became clear that many were finding this process difficult the teacher challenged them to pay attention to her further explanations and hypothesized about ways in which the elements of the natural forms could be used to enhance and develop the pupils design work through comments such as 'Yeah, you don't have to use the whole thing. It doesn't have to look like it. You can choose bits of it, okay?' During this interaction the teacher affirmed the pupils' thinking and gave feedback on any ideas which they put forward. This led to

some very rich interactions which enabled the pupils to understand exactly what was required of them. This willingness to set tasks and revisit the process in this context is a very powerful way of enabling the class to do well at the task in hand. When the pupils went back to working on their own designs the teacher interacted with them on a one to one basis, challenging them to ensure that they were meeting the requirements of the task, explaining these again where necessary and questioning pupil choices by asking them to explain where their design ideas were derived from. One example of this form of interaction begins with the teacher speculating about the pupils work 'So, what we're going to incorporate into this is,' explaining through a comment such as 'right you need to go over it a little bit harder,' elaborating by explaining that the pupil needed to 'put your straps on it and then turn it over and you can process it, yeah?' This brief interaction led to significant gains for the pupil which could be considered to have expanded her 'zone of proximal development' (Vygotsky, 1978; 1981; 1986) or in this case her 'zone of designerly proximal development' (Trebell, 2007) via interaction with a more competent partner in this case the teacher, the result of which was clearly shown by the pupil punching the air and exclaiming 'yes' when she managed to achieve something she had previously struggled to do. The teacher went on to have a number of these kinds of interactions with the pupils in her class ensuring in each case that the pupils were enabled to extend their work through her intervention. Throughout these interactions the teacher was very good at allowing the pupils to articulate their thinking as can be shown in the next statement 'Oh I know what you could do. You can have it so that you have to pull all of the strings up. So you put it in that way instead of putting it in that way'. The teacher

responded in each case with praise for example 'Oh, that's a nice idea' often accompanied by further challenge such as, 'How will you change the straps?'

Having given the pupils some time to complete the second drawing, the teacher explained what she had done with her design 'So, this is my bag at the end of section two, okay? I've changed the straps completely, look at the board. I've changed the straps completely, I've put my own design and then the clasp is some kind of clip now that's going to happen around there, and I might have some other strap, tucked out of the way as well. So, it is completely changed. I'm not stuck with my shoulder straps being stuck where they are. Some of you have changed it to having one strap or changing the straps so they're in different directions and that's great. Um, I've also got my mesh that I'm going to have on the front, which will have a rubberised screen, to fit onto the front here, so that I can hold things onto it if I want to, or maybe enhance things on it, or whatever, it is entirely up to the person who is going to use it' This served to model the teacher's thought process and to explain the changes that had occurred. She then went on to explain how she might use words such as dripping and swelling to enhance her design work further with comments such as 'So, say dripping, now what I'm going to do for my bag, is I might make it um look like it is coming down a lot more, so I might have a section that could be either at the bottom [?]. It doesn't matter how silly it looks at the moment, it is just all...go around the sheets[?], and I might have, it might be quite spherical, and I might have maybe a water carrier, that fits onto the bottom of the bag, and it can be attached on here somehow'. Through this modelling process, the teacher speculates on what she might do, explains how she will go about it and elaborates on her thinking as

she develops the design idea on the board. Throughout this process the teacher challenges herself to improve the design work, evaluates what is being produced and reflects on how effective it is. The combination of both cognitive functioning and language functions is very powerful in expressing the complexity of designerly activity.

As a plenary towards the end of the lesson, the teacher asked the pupils to explain their design work to the others on their table. They had to do so with reference to the stimulus material and in a way that their peers could understand. The following explanation from one pupil is typical of the type of feedback received, 'I have changed from two straps to one strap. I have done it so it goes around you instead of over you. I have changed it from that sort of shape, an oval shape to a whole circle. Instead of opening it from the top you open it from the side' which in my opinion shows that the pupils engaged effectively with the task and were able to develop their design work as a result of this.

The teacher finished the lesson off by inviting certain pupils to explain their work to the rest of the class. One pupil gave the following explanation, 'I put a holder, I put it at the back of it, instead of taking the bag off it has a bottle of water and in the bottle of water, a straw that goes over your shoulder through that, like that. And then it has an I-pod holder, to listen to your music' which shows the diversity of thought and the quality of ideas that were being produced by the class. The interactions at this point consisted of explanations from the pupils and questions from the teacher in order to ensure that all details were included. The teacher also affirmed ideas and openly reflected on their quality as well as challenging some members of the group to pay attention during this phase of the lesson.

4.5.8 Analysis of Learning Conversations in lessons 9 and 10

When analysing the video data for lessons 9 and 10, transcripts of which are included in appendix 4F, it is interesting to note what appears to be a well established pattern of the teacher beginning the lesson by reflecting back on the work from the previous lesson. During these interactions the teacher engages in explaining, questioning, affirming and speculating strategies in order to achieve the kind of dialogue that she requires. Having reflected on the pupils' prior learning and established that the pupils have not learnt as much as the teacher would have liked, she shows excerpts of each of the films in turn explaining and using further questioning techniques to ensure that pupils understand the materials being studied. In each case the teacher makes the pupils take notes regarding the name of the technology being studied and possible uses which appears to be a very good idea as the information can be used by the pupils in the future to justify the use of the technologies in their design work.

Having reviewed clips from the films the teacher then got the pupils to gather around the front desk in order to show them examples of design sheets produced by her group in the previous year. She began by explaining the concept, technology used and who the product was designed for. In each case she elaborated on requirements with comments such as, 'So, you need to draw your product, so that you can understand what it is. You need to be able to write lots of notes on it, to also explain what we're doing'. She went on to speculate as to the sort of products the pupils may design, to reflect on the quality of the work produced, to question the technology used and to challenge the group to think of alternatives.

Having reflected on the existing products, the teacher went on to talk about who the pupils could be designing for and what technology they might incorporate into the design with comments such as 'How could these type of technologies help with sport? How could it help maybe with injuries?' She then began to challenge the pupils with questions such as 'How can it help with people getting them onto a field or getting them off the field in a safe space'. This interactive approach challenged the pupils to think about a wide range of possibilities without actually telling them what they had to design.

The teacher then explained that the group would use the notes made when studying the films to help them come up with their own ideas. She talked about layout of the sheets and the details that should be included.

At this point the learning conversations became pupil/pupil in nature as the group returned to their tables to get on with their work. In these small groups the nature of the conversations involved speculating through comments such as 'I could do something for an older person with back problems'. During this phase of the lesson the pupils were also very good at praising each others ideas. The teacher used this opportunity to work her way around the room giving feedback to individuals through comments such as 'How can you programme it?' which challenged them to think more carefully about the ideas that they were proposing. During this stage the pupils shared ideas with each other thus scaffolding each others work and enabling each other to produce work of a quality that would not otherwise have been achieved. At the end of the lesson the teacher asked pupils to explain to the whole class what they were actually producing. They did this very

sensibly and she took the opportunity to elaborate on their feedback so that the information gained by the whole class was a little more detailed. Throughout this part of the lesson the teacher utilised praise in order to get the very best out of the group.

4.5.9 Analysis of Learning Conversations in lessons 13 and 14

When analysing the video data for lessons 13 and 14, transcripts of which are included in appendix 4G, it is interesting to note that the learning conversations within this lesson began with the teacher explaining what the group did during the last lesson and swiftly moved on to explore how pupils can consider the physical, intellectual, emotional and social needs of their clients when designing products for the future to meet specific needs. At this stage the teacher questioned the pupils understanding of PIES and then challenged them to make this relevant to their own work through questions such as 'what need would you identify for your T-shirt? What is the end...what is it going to do..what does your T-shirt do?' to which the pupil answered 'Well, it was going to display different logos, bands etc' to which the teacher replied 'so your market then that you're looking at is maybe more the intellectual or the social bit, so that people that wear t-shirts that have got the same band name on it or wherever, and then you can strike up a conversation, because you know that they like the same thing. So, it could encourage the social needs'. Through speculating about the users needs the teacher is able to model her thought processes so that the pupils can emulate this in their own design work.

Having reflected on the progress of the pupils' designerly activity in the previous lessons, the teacher was concerned that some of their design work was not as well presented as it

could be. In order to overcome this she got the pupils around one table in order to carry out an input on presentation techniques. During this interaction the teacher unintentionally used protocol analysis to reveal/model her design thinking to learners. Protocol analysis is well used by researchers undertaking research into the work of professional designers (Bilda et al, 2006). Interestingly she chose to contextualise the input by taking one of the design ideas of a pupil in her group. By doing this she was able to explain what she was doing, evaluate the process as it progressed and reflect back against what the pupil had achieved. This opened up opportunities for speculation and challenged the pupils to reflect on their own work and to decide if this was acceptable or if it needed to be changed in order to meet the high standards required.

Throughout the interaction the teacher was very clear about what she was trying to achieve and covered many techniques to assist this, from the use of shading to exploded views of key features supported with detailed annotation. At the end of the input the pupils returned to their seats and some were noted to make comments such as 'I am going to do it again', signalling that they had decided that it was possible to do their work more effectively.

The teacher then moved into teacher/pupil interaction as she circulated within the room supporting pupils on a one to one basis. She often used sketching to support interactions using a mix of questioning, elaborating and evaluating. This form of interaction enabled pupils to progress and to feel that they could with the support of the more competent designer produce some excellent work. The teacher also speculated a great deal on the

form that ideas might take. She did this very carefully taking the time to ensure that the ideas remained the property of the pupil and as such were not hijacked through her thought processes which is really important as pupils are very clear that they want to feel ownership of their work if they are to pursue a task to completion.

Within the interaction sequence it is interesting to note that a number of pupil/pupil interactions were evident where support with design ideas in the absence of the teacher was sought from peers. This was also an interesting example of the zone of proximal development (Vygotsky, 1978; 1981; 1986) having been enabled within this classroom through the nature of the interactions encouraged. In one case this was exemplified when one pupil helped another to draw a person leading to the owner of the design work explaining 'Oh so that is why my people never look right, because I always give them a circle head' showing that the pupil was evaluating the design work and reflecting on her previous achievements.

The teacher then challenged pupils to think of interesting titles for their design ideas by thinking out load as she reflected on possibilities, for example 'It is to do with badmington, it has sensors on it. It helps to improve your badminton skills, um...' and speculated about what these might be if the pupils were having trouble thinking of their own, for example 'Teach me racket, badmington'. Throughout the interactions she remained approachable to all pupils as well as being challenging to any who were off task. She also used the challenge of time limits to maintain pace and made it clear through explanation that the pupils were going to be expected to show their work to the

rest of the class at a given point. This led to many actually getting back on task in order to avoid having nothing to show. The other form of very effective interaction which the teacher engaged in, related to technical knowledge; she was not content with images and wanted pupils to justify the technology they would use, reflecting back on the films they had seen to help them. She engaged in the following kind of interaction sequence in order to achieve this aim, questioning 'so what are we having on the screen?' reflecting back on prior information 'Do you remember we said before that we could have a bio-sensor?' and explaining further 'so you could wet your finger and then put it on that pad so that you can have a sensor'

At the end of the lesson the group brought their work around one table and the teacher took the time to give feedback on what had been produced, evaluating outcomes and giving further challenge as she went along. This sought to confirm that she was happy with the pupils' progress but that the work could be further improved. This mix of praise and challenge is typical in the work of this teacher, as are good relationships with pupils and effective behaviour management techniques.

4.5.10 Analysis of Learning Conversations in lessons 15 and 16

When analysing the video data for lessons 15 and 16, transcripts of which are included in appendix 4H, it is interesting to note that this lesson began with the teacher explaining what the pupils had to do but also challenging the poor behaviour of some. She then used questioning and discussion to work out what information pupils needed to add to the powerpoint presentations that they were going to produce once the design sheets were

finished. She used questions such as 'what will give your work the greatest impact' in order to involve the pupils in the decision making. Throughout the questioning the teacher gave the pupils feedback on their answers and also elaborated on the information given in order to give more detail. This approach enabled the pupils to see that their thoughts were valued but that it was necessary to take the thinking further in order to reach the standards required. In summary the teacher highlighted that the pupils would need all of the following in order to produce an effective design sheet: 'catchy title, price, you don't need to worry about that too much but I am not going to knock it off as it is important for some things; colour, a nice picture of what you're doing. Also, detailing your picture. Remember that we're looking at exploding areas to make it bigger, if we talk about one little area. Different styles maybe or pictures that you have there. Say what it does, who it is for and the instructions on how it works. Anyone else got something about a packaging on there?' This overview of requirements set the scene in terms of expectations enabling the pupils to return to their seats and complete their own work. It should be born in mind that the thinking was co-constructed, the teacher did not dictate from the front what was required; she worked through questioning with the pupils to construct what was required.

In order to exemplify requirements and as reinforcement to what had taken place the teacher put her own design sheet on the board, this was the same sheet that she was working on the week before but she had taken time to develop it further in between lessons. She then talked through her thinking about the work thus modelling this process.

The pupils then returned to their desks and carried on with their work. At this point it was interesting to witness the pupils' reactions to the discussion with one pupil noting 'mine doesn't look good. I am not sure what I am doing. I have got to change this' This uncertainty led to a discussion with her peer where both pupils interrogated the work. Through the interactive dialogue of the two pupils, a way forward was found and the pupil was able to continue.

The teacher then started working her way around the room once again undertaking one to one interactions with the pupils. At this point it was clear that she had a number of concerns about the work and used questioning to address these. The issues included ensuring that the work was well presented, ensuring that the pupils understood what sort of technology they were going to use and how it worked. The modes of interaction were questioning, explaining and speculating as the teacher challenged the thinking of each pupil in turn. However in the following interaction the modes became even more complex, 'So think about planning it out. Where might you put things? So you could keep this like this and then put that there', making use as it does of questioning, challenge, evaluation, feedback, elaboration and speculation within a very short interaction which illustrates just how complex classroom interaction during designerly activity actually should be if effective results are to be gained.

The main part of the lesson was full of this sort of interaction. In addition the pupils were interacting with each other at their tables with explanations of their thinking such as 'I am thinking of doing the outside yellow, what do you think?' to which pupil C replied 'yes,

that is good'. This sort of peer to peer interaction served to challenge each others thinking and to enhance possibilities.

Another important set of interactions were linked to the physical ways in which things are developed and what sort of techniques can be used to enhance the quality of the design work. In the following example the teacher explained what was required, illustrated how to achieve the aim and challenged the pupils to go head and do what was required. 'Right what you need to do is put this tracing paper over here and copy this through. Then we can present it more like the one on the board. OK'. There are many examples of this type within the data some of which were led by the teacher and others by the pupils, showing that within this classroom, pupils were encouraged to adopt the role of expert when they had relevant information.

Praise such as that given in the following statement is also well used to encourage the pupils 'This is looking lovely. So is this and this. Well done! You are doing very well' which without doubt helped to keep pupils on task and to ensure that they completed the work required of them.

The main part of the lesson was particularly rich in a range of categories of interaction. The teacher speculated regularly with a view to modelling her thought processes and showing how ideas could be stretched. She explained concepts several times until pupils understood them, elaborated on pupils' work using questioning to get them to take their thinking further, affirmed their thinking with praise and other forms of feedback,

challenged their thinking after evaluating its effectiveness and reflected on possibilities throughout the dialogue. As such one can conclude that within the classroom really rich learning conversations were taking place which enabled pupils to value what they had produced but to push themselves to go further with their work. There is a strong relationship between the quality of the learning conversations and the quality of the final outcomes, which for a low ability group, are of a very high standard.

At the end of the lesson the pupils gathered around one bench with their work. The pupils were challenged through questioning to study each others design work with a view to articulating what they liked about it. The pupils did this with ease showing that they are used to working in this way. The teacher also used the plenary session to praise the pupils for their efforts.

4.5.11 Analysis of Scaffolding and Mediation

The data will now be analysed from an alternative perspective in order to ascertain the extent to which the use of scaffolding and mediation are important features of classroom interaction during designerly activity. In certain instances this will necessitate re-examination of elements of the text in order to scrutinise it through a different lens. There are a great number of different forms of adult mediation, from the adult's presence, which provides the child with a secure learning environment, to encouragement, challenge, and feedback (Schaffer, 1996). Tharp and Gallimore, (1988) wrote about such forms of teacher mediation as modelling, contingency management (praise and critique, feedback, and cognitive structuring). In analysing the data, quotes from the transcripts in

appendices 4I, J, K and L have been citied in order to clarify the points made. These quotes have been marked in red on the transcripts for ease of reference.

4.5.12 Analysis of Scaffolding and Mediation in lessons 3, 4 and 5

When analysing the video data for lessons 3, 4 and 5 transcripts of which are included in appendix 4I, it is interesting to note that the lesson began with the teacher encouraging the pupils to think about PIES and to recall what the individual letters mean. This is quite challenging for this class as they are of very low ability but the adult presence and cognitive structuring achieved by breaking the words up through directed questioning such as 'What does P stand for in Pies?' helped the pupils to answer the teacher's question during a whole class discussion. When each question was answered the teacher gave feedback which encouraged others to take part.

Having concluded the starter the teacher introduced the pupils to the four Rs of creativity and challenged them through cognitive structuring to think about the different types of carrying devices that exist. She began with their school bags and when they did not answer as effectively as she would have liked, modelled the process for them by asking them to show her their school bags, she then made a list on the board of the various types that exist. Having modelled the process the teacher challenged the pupils further by asking 'What other types of bags are there?' When receiving the pupils' answers the teacher made good use of praise, feedback and encouragement in order to extract the most effective information. When she thought their input was running out she modelled the process further by adding 'handbags' and asking 'So, what else might other people need when they need to carry?' This question gained an answer and kick started the pupils thinking once more, which led to further discussion about different types of bags. This discussion continued for some time and led to the development of a very informative

and detailed mindmap, the development of which was supported through praise, encouragement and the constant interaction of the teacher.

When the discussion was over the pupils were told to write the mindmap in their booklet so that it could be referred to at a later date. Whilst the pupils wrote this up the teacher circulated around the room making her presence felt and encouraging the pupils to get on with what they had been asked to do. This approach was vital with this group who easily lapsed into off-task behaviour if they were not watched constantly.

Once the pupils had finished writing the mindmap in their booklets the teacher used cognitive structuring to challenge them to draw their school bag in an effective way in the space available in their booklet as the first stage of the four Rs of creativity. In order to help them do this, she modelled the process by using one of the pupils' bags as an exemplar, drawing it on the board whilst talking through what she was thinking as she did so.

The pupils then started drawing their own bags. At this point the teacher entered into individual pupil/teacher interactions, making comments such as 'I'll do the bottom bit and you can do the rest' in order to encourage the pupils to get the drawings done and to ensure that they were of a high standard. She also gave feedback such as 'Okay? But you need to be neat and you need to be clear'.

Having overseen the first drawing, the teacher modelled the process of developing a design drawing by taking elements from an inspiration sheet and incorporating them into the work. During this demonstration she explained her thought process as she went along. Although the means of expression was not particularly fluent here, the drawing on the board clearly exemplified what the teacher wished the pupils to do.

The pupils then started to develop their own design idea and the teacher went around the class helping them on an individual basis with comments such as 'I might do some detail on the side. This eventually could be string with a toggle that you could fasten something into, okay?' Using a combination of modelling, presence, encouragement, challenge and critique to help pupils, achieve the required result. During this stage the teacher was also seen to model various graphical techniques such as the use of tracing paper in order to help the pupils move their design work on. Through constant monitoring, the teacher came to realise that the pupils did not fully understand what was required of them. In order to address this she called their attention back to the board. During this explanation the teacher again used cognitive structuring as she modelled her thinking and critiqued her work as she went along with commentary such as 'So, you might like the pattern that one of them has, and it might be a nice, bobbly pattern ..... You might have a bobbly pattern on the bag ..... that you want to incorporate onto your rucksack'.

With the task redefined the pupils returned to their desks and continued with their design ideas. The teacher continued to circulate and interacted with the pupils critiquing their work whilst giving feedback and challenge for example 'Try and get it a lot bigger on this

side, so...instead of it being that size, you need to...' The pupils were now able to proceed with this element of the four R's of creativity and did so very effectively.

In another interaction 'Do you expect this to be crossing over to the side [unclear]. Do you think it would be like, like do you think it will have a big pom pom, or do you think you might sew some of it?' the teacher was modelling her thinking whilst giving feedback and challenge. The pupil responded well to this by commenting 'no just free' to which the teacher responded 'just free all over, sounds like a nice idea', which served to praise the pupil for her efforts. In another example of interaction the teacher was talking to a more reluctant pupil 'You can have it yes, fantastic. Try and change the shape of it as well, um Josh. So, if you've got the time you can make them really big, and make it like it has got a shell' to which the pupil replied 'I don't want to have them all the way around...' showing that he was beginning to think carefully about the task in hand. The combination of praise, challenge, modelling and feedback proved very effective once more.

With the pupils now developing the work effectively the teacher began to challenge them further to think about the detail of what they were designing through comments such as 'Oh, that's a nice idea. How will you change the straps? [unclear]' to which the pupils responded, 'I don't know. You could do one that goes across their' illustrating through words and gesticulation that she was pleased with her idea.

As the pupils completed the development of their design work the teacher drew their attention back to the board and began by summarising how she had developed her bag. Having modelled her thinking the teacher moved onto the next step of the developmental process which involved using words like dripping and swelling to prompt thinking which would assist further development. Again she modelled the process on the board saying 'You've got swelling, so I might have one of the straps. ..... Probably, one of the straps I might change, and make a lot bigger than the other one, okay?'

At the end of the lesson the pupils were asked to explain their design development to the people on their desk and then at least one person from each desk shared this with the rest of the class. The pupils comments consisted of statements such as 'Well, I've done...I've changed the strap and I've used the...this from this sheet, and then I opened it with [too soft] so you can use it for [too soft]' to which the teacher replied 'So, you used the starfish to, to change the clasps, to get your bag open'. Throughout the plenary the teacher challenged the pupils thinking further to ensure that she gained a full explanation of what they actually did. This was accompanied with a great deal of praise to which the pupils responded very well.

4.5.13 Analysis of Scaffolding and Mediation in lessons 9 and 10

When analysing the video data for lessons 9 and 10, transcripts of which are included in appendix 4J, it is interesting to note that this lesson began with the teacher undertaking cognitive structuring in order to get the pupils to reflect on the work that they did in the previous lesson. This was achieved through challenging questions which made the pupils

think back to prior learning. The teacher made good use of praise to encourage the pupils to take part throughout the question and answer session. The pupils were then asked to make notes on each of the smart and modern materials in the film. The teacher structured this note taking by outlining what pupils needed to do for example 'you need to be noting down again what the name of the technology is, and its possible uses'. In doing this she made sure that the notes taken were not left to chance and that all of the pupils gained appropriate information. During the note taking the group needed encouragement to stay on task but managed to do so effectively.

The teacher then asked them all to come around one table so that she could introduce them to the next task. She began by showing them examples of design work produced by pupils in previous years. As she did this she used cognitive structuring to get them to think about the task by deconstructing what the previous pupils had done. The teacher then began to challenge the group to come up with their own ideas by modelling the process with comments like 'so, how can you incorporate...it doesn't have to be in clothes, but also when you think about your product, think about your user group, so, not just about yourself. So, you could be thinking about um women with children. You could be maybe incorporating something that might help children into their push chairs'. The teacher structured the pupils thinking by getting them to mindmap different types of user groups, they did this very effectively concluding in the production of a detailed mindmap on the board through comments such as 'what do you like doing in your spare time. Football, so you could look at sports'. When the user groups had been identified the teacher began to discuss the products that could be produced, the needs that might be met

and the technology which might be used to achieve this goal. Throughout this part of the lesson there was a good mix of modelling, challenge, praise and encouragement which maintained the collaborative flow of the development of the mindmap. During this session most of the class contributed and it was very clear via the energy in the room that the pupils were enjoying coming up with the ideas. Having completed the mindmap the pupils were asked to return to their places in order to take notes from the board.

When the note taking was complete the pupils returned to their tables where they began to discuss their ideas with their peers. It was clear at this point that the ideas were being drawn from the collaborative mindmap which had been produced thus making it a useful tool in the generation of ideas. At this point the teacher worked on a one to one basis with each pupil in order to help them generate their design idea challenging them through feedback and critique such as 'Instead of having the little speaker things at the side of the bed' to which the pupils replied 'Yes it is just the same but it is in here' Throughout this stage of the lesson there was an interesting mix of pupil/pupil and pupil/teacher interaction which led to the scaffolding of ideas through effective forms of mediation. At this point the teacher also helped the pupils with their drawings where necessary in order to ensure that they enjoyed success and were not inhibited by their lack of drawing ability.

During the plenary the teacher encouraged each pupil in turn to explain their design idea to the rest of the class. At this point she used praise very effectively and where necessary

built upon the pupils' explanations in order to exemplify the depth of response she required. So the interactions were a mix of praise, encouragement and feedback.

4.5.14 Analysis of Scaffolding and Mediation in lessons 13 and 14

When analysing the video data for lessons 13 and 14, transcripts of which are included in appendix 4K, the lesson began with the teacher recapping PIES and reminding pupils that they should be designing for a specific market and to meet an identified need. The teacher used praise, modelling and cognitive structuring through comments such as 'you must have your overall design on here and then we must have close ups of what you're doing to all the bits, okay?' to remind the pupils of her expectations regarding the design sheets. She then spent some time modelling the production of an effective design sheet with the pupils watching. Throughout this work the teacher talked through what she was doing and challenged the pupils to think about the quality of their work with comments such as 'So, with my arrow pointing here, I can either draw or I can just do it to a text box' The teacher concluded this part of the lesson by explaining that the pupils were going to present their ideas to the rest of the class which meant that they had to be of a very high standard.

When the pupils returned to their desk they began to reflect on their work which led some to decide that they were going to start again indicating that seeing the teachers work had made them reconsider the quality of their own work.

The teacher then made her presence felt as she went around the room challenging the pupils through interactions such as 'So now what are you going to do? You need to explain what all this is, and this' and critiquing through comments such as 'So you need to say that your design is easier to use. OK' Throughout the one to one interactions the teacher was full of praise for the pupils' work which helped to keep them motivated. During this part of the lesson the pupils took part in pupil/pupil interactions in order to support each other in the development of their design ideas. Following a request for help, one pupil asked another on her table 'what do you want me to go around. Those two' to which the other pupil replied 'yes' and then proceeded to work with the first pupil in order to progress the design work. Through this interaction the first pupil scaffolded the learning of the other through interaction and the co-construction of the design idea.

During this stage the teacher was very keen to ensure that the pupils' presentation was good and as such she spent time getting them to think about suitable titles, colours, the use of exploded views to show detail etc. In one case the teacher modelled her thinking about the development of a suitable title by saying 'It is to do with badminton, it has sensors on it. It helps to improve your badminton skills, um…' which led the pupil to suggest the title 'Teach me racket, badminton' a title which he went on to use. At the same time a pupil had a conversation with one of her peers, they named the product and then informed the teacher 'Miss I have helped Hannah name hers. It is going to be called sleep tight baby cot' which was met with praise from the teacher.

As the group were of low academic ability, the teacher and in some cases the pupils, spent time helping out with spellings as the pupils were keen to get this right on their design work. This was really interesting to see because the pupils were so proud of their work that they did not want poor spelling to ruin the overall design sheet.

During the plenary the teacher made a point of praising the pupils for their hard work once she had all of the pieces in front of her and the group gathered around her. This served as further encouragement for them and was a very effective way to end the lesson.

4.5.15 Analysis of Scaffolding and Mediation in lessons 15 and 16

When analysing the video data for lessons 15 and 16, the transcripts of which are included in appendix 4L, the lesson began with the teacher explaining, 'this lesson, I want you to finish getting those (design sheets) presented up properly, and we're going to put them onto powerpoint, and you're going to do a proper powerpoint presentation'. She then went on to use a mixture of encouragement, feedback and critique in order to co-construct a list of things which needed to be on the presentation in order to make it effective with comments such as 'Okay, you can put your instructions and how it works. You can put packaging if you want to, how are you going to make it eye catching?' Throughout the whole class discussion, the teacher made a point of using questioning to challenge the pupils thinking and praise as a means of encouragement. However, with each new input from a pupil' the teacher gave feedback and built upon the answer in order to scaffold the pupil's thinking.

Next the teacher placed the design sheet that she produced the previous week on the board. In between the two lessons the teacher had completed the sheet which served to model the process. She then went on to critique her work 'so it is my t-shirt at the side, and then I'm putting in boxes all the different areas that I need to look at' serving to illustrate that the generation and development of design ideas requires ongoing iterative thought in order to produce good results. She also pointed out the information that she had added to the sheet and concluded by stating that they needed to produce 'something nice, bright and catchy but something that's well presented'.

As the teacher explained that the pupils were going to complete their design sheets she used lots of positive feedback for example 'Okay, you are still producing excellent work. You have come up with some fantastic ideas', in order to encourage them to continue to work at the same high standard they had currently adopted.

The teacher then began to circulate, interacting with pupils on a one to one basis saying things like 'We have been basing these around the films which are around new technologies. So we've got things like shape memory metal which will change shape so you can have it there' in order to remind pupils that they had to explain which type of technology would be used in their product. She also showed a great concern for the overall quality of the presentation and using feedback such as 'If you are going to do it like that maybe you could just change this bit' challenging pupils to improve their work further.

As the teacher moved around the room she helped pupils by modelling the development process either on their sheets or on separate pieces of paper. This once again enabled the pupils to see how they might progress for example 'So maybe you can have the bike and then you can have the person with the suit that they wear which has leather which would on impact go harder'. With the teacher modelling this way of working it is not surprising that the pupils also interacted with each other in order to scaffold their learning with one pupil saying 'what does that say' to which his peer replied 'Marty's T-shirt' and the first pupil said 'that isn't a T. that is an H' which led the first pupil to correct his mistake and thus improve the quality of his work.

The teacher continued her interest in detail by asking one pupil 'What is it? How does it work?' with a view to challenging him to share appropriate information on the design sheet. In another case she challenged the pupil to study the sheet she had designed and put on the board on which she had modelled the process, she used cognitive structuring to help focus their thinking and critique to get them to understand what she thought of the design sheet through the following dialogue 'Okay, we need to highlight some of this don't we. Look at that sheet you need to be using some of the ideas from there. So you can highlight around here. Come on this is a really nice sheet. If you want to you can do the highlighting in pencil crayon'

During this part of the lesson the teacher worked her way around every pupil ensuring that they all benefited from the one to one challenge. In another case the teacher critiqued a pupils' work feeding back with 'Excellent, are you going to have details of what he is

going to have in his helmet. Is it so that you can contact other people?' to which the pupil replied 'Yes' and the teacher responded 'It would be useful if there was a phone type thing in the helmet, don't you think. You could do it so that it is voice activated so it will work when you say something like, phone' and the pupil said 'I am not sure how I could do that' to which the teacher replied 'Well you could have it so that it is multi-functional and you have to work through the menus to use different functions'.

The plenary was conducted by getting all of the pupils around one desk with their design sheets. The teacher began by saying 'You've all got an extreme range of products which we said before, and you have all worked through them to bring up some fantastic ideas.' showing that she was very pleased with the pupils work. She then asked the pupils to choose a design that they liked and to critique why they liked it. One pupil said 'I like the horse coat one' to which the teacher replied 'Kirsty, why do you like the horse coat one?' and the pupil said 'because it stands out.' The teacher summed up the plenary by saying 'so we can see that Danielle's has something to do with horses, we can see that because it says what it is on there, and this is to do with babies. Mark's, we know he is doing T-shirts. Tiffany's is something to do with pillows. Josh is something to do with choppers and you'll make it more obvious later on. Hannah's is obvious, Ruby's is obvious, John's is obvious, Lucas' is obvious, Ben's is obvious' reinforcing how pleased she was with the pupils design work.

4.5.16 Analysis of Emergent categories

The data will now be analysed from an alternative perspective in order to ascertain the

extent to which the emergent categories identified are important features of classroom interaction during designerly activity. In certain instances this will necessitate re-examination of elements of the text in order to scrutinise it through a different lens. There are nine emergent categories which have been derived from the data collected to support this study. These consist of **teacher gesticulation** – using body language to help make one's point, **use of visual stimulus material** – laminates, **use of visual stimulus** – films, **interactions to modify pupils poor behaviour**, **making use of existing products** for example pupils school bags, **use of graphics kit** that is tracing paper, felt pens etc, **exemplar material – showing examples of other pupils work**, **exemplar material – using the teacher's own work** to show the level required and **pupil gesticulation** – using body language to help make one's point. In analysing the data, quotes from the transcripts in appendices 4M, N, O and P have been citied in order to clarify the points made. These quotes have been marked in red on the transcripts for ease of reference.

4.5.17 Analysis of Emergent categories in lessons 3, 4 and 5

When analysing the video data for lessons 3, 4 and 5, the transcripts of which are included in appendix 4M, it is interesting to note that the lesson began with the teacher encouraging the pupils to reflect on the meaning of PIES. She broke this down into the individual letters and targeted pupils by name through questioning in order to gain answers. At this point the teacher was not making use of any items identified in the emergent categories.

Next she talked to the pupils about the task that they would be undertaking and got them to think about different types of carrying devices. In order to support their thinking at this point she got each of them to collect their bags from the rack and to place them in front of themselves. In doing so she made use of existing products to inform pupils' thinking. This enabled them to mindmap a wide range of school related bags. Having made a good start on the mindmap, the teacher was able to encourage the pupils to start thinking about other users who need bags, the sort of things they might carry and what sort of bags they might have. Having dealt with familiar carrying devices the teacher prompted the pupils to think about the carrying devices that might be needed in other cultures and what sort of products might be used. The pupils worked well with the teacher at this point in order to develop a very detailed mindmap which they were all then asked to copy down into their booklets.

Having told the pupils that they needed to copy the mindmap she had to use behaviour related interactions such as 'Sit down please. Where's your pen? Can you get one?

Good, excellent' in order to get some pupils to return to their desks and do as they were told. This is typical of the group being studied many of whom have poor literacy skills and use a range of diversion tactics to try to avoid having to do any writing. The teacher is well aware of this and knows that the pupils can all write and therefore she will not condone them simply avoiding the task. She also had to threaten punishment such as 'some of you are wasting a lot of time which means that you might be spending time in the break with me' in order to get the really defiant pupils to do as they were told.

Next the teacher introduced the pupils to the four R's of creativity explaining that they had to begin by drawing their own school bag. In order to show them how they might do this and the standard of work required, she took one of the pupils' bags and drew it on the board thus using the teacher's work to set the scene in terms of the requirements of the group. Having shown the group what the drawing could look like she asked them to draw their own school bag in the space available. She then circulated around the room helping each pupil in turn. At this point it was interesting to note that the teacher used gesticulation a great deal to make her point, exemplifying a statement such as, 'that line goes that way, and that line has to go that way, okay? And then you can follow that around' by showing what she meant with hand movements across her body.

When the pupils had completed the first bag, the teacher drew their attention back to the board and once again used her own work to show them how they could take images from the laminates available and use these to develop their design ideas. Following the latest explanation the teacher circulated once again interacting on a one to one basis. At this

point she ensured that pupils had a good range of graphics equipment to work with such as tracing paper because she knew that by providing this she would give the pupils a better chance of success. She also had to explain how the laminates containing images of natural forms could be used effectively to develop the design ideas as some of the pupils were taking whole shapes and just adding them on as pockets rather than considering how the shape could be used to transform the bag. Once again the teacher had to use interactions to modify poor behaviour but she proved herself to be very consistent with this which meant that on the whole the pupils remained on task and did what they needed to do.

Taking the lead from the teacher, several pupils were noted to use gesticulation when explaining their design ideas to the teacher. This seemed to act as a third way for them as they were neither particularly articulate nor fluent at sketching and so the third means of communication, allowed them to use kinaesthetic interactions to explain their thinking. The teacher responded with her own form of gesticulation accompanying a comment such as 'do you expect this to be crossing over to the side' with an arm movement across her body. At one point it was clear that the pupils were struggling to understand what was required of them so the teacher drew their attention back to the board and went through the concept again using her own design work to exemplify the process. When the pupils continued with their work the teacher made a point of asking them which elements of each laminate they were using and how they were incorporating it into their bag. Another very good example of pupil gesticulation was a pupil moving her arms up and down as she said 'Oh I know what you could do. You can have it so that you have to pull all of the

strings up. So you put it in that way instead of putting it in that way'. This enabled the teacher to understand what the pupil meant.

The teacher then used her own work again to explain how she was going to move onto the next stage of the 4rs of creativity. The pupils started this but did not get far before it was time for the plenary. During the plenary the teacher asked the pupils to explain their design work to the others on their desk. One pupil said 'I have changed the straps. I have changed it so that you use string to close it. I have also changed it in to a circle' throughout this explanation the pupil gesticulated in order to reinforce her statement. Several pupils were then asked to present their work to the whole class. In every case they explained what they had done but they made good use of gesticulation so it would appear that this is an important designerly tool at this stage in a fledgling designer's development.

4.5.18 Analysis of Emergent categories in lessons 9 and 10

When analysing the video data for lessons 9 and 10, the transcripts of which are included in appendix 4N, it is interesting to note that this lesson began with the teacher reminding the group about the smart and modern materials that they studied the week before. She then went through each material in turn and got the pupils to make notes of the names of the material, how it worked and what products it was used for. At this point again because the pupils do not like writing, the teacher had to use behaviour related interactions to keep some of them on task. She then went on to use visual stimulus in the

form of the films to introduce the pupils to more smart and modern materials which they could make use of in their design work.

Having completed the note taking, the pupils were asked to gather around one desk and the teacher made use of other pupils' work from previous years stating, 'these are some examples from last year's group, based on exactly the same things that you've been watching today' in order to explain what the latest group had to do. One or two pupils were less than attentive at this point so the teacher had to intervene by stating 'I've asked you to stop acting like primary school children' to get them to focus on the task. She did this effectively and the discussion continued. Next the teacher started to mindmap different markets such as disabled, parents etc and their individual needs using questions such as 'Who else can we design for?' in order to get the pupils to engage in the activity. Having done this, the group began to discuss the types of products that the pupils could do and the smart and modern materials which could be used to make them successful for example 'But you could have a ball that maybe has sensors in it, that will say whether it goes over the white lines or something'

Having completed this discussion, the pupils returned to their desk and started to design their own product. The generation of ideas at this point was supported through pupil/pupil interactions where the pupils helped each other to decide what they were going to do for example 'I am doing a scanner so that you can see your baby. Good isn't it'. The teacher then worked with individuals challenging them through questioning to come up with good ideas for a specific market to meet a need that they could clearly articulate. At this

point the ideas of other pupils and the collaborative mindmap were important factors in getting the pupils to generate effective ideas of their own.

During the plenary pupils shared each others' ideas by telling the class what they were going to do for example 'It is a pram which senses when the baby is upset and rocks it' and 'I'm doing a badminton racket which tells you how many times you've hit it, whether it is good or bad hit'.

4.5.19 Analysis of Emergent categories in lessons 13 and 14

When analysing the video data for lessons 13 and 14, the transcripts of which are included in appendix 4O, it is interesting to note that this lesson began with the teacher reflecting back on what the group did the week before. At this point some of the pupils were finding it difficult to settle down to the work in hand which meant that the teacher had to use behaviour related interactions such as 'So be quiet then' to get them to settle down. This worked effectively and the group were then able to get on with the work in hand. The teacher drew on the pupils' ideas from the previous lesson by asking them to explain what they had designed through interactions such as 'What was the market, what is the market that you're designing for' to which the pupils replied 'well, it is for hikers' Having talked about several of the designs the teacher praised the group by stating 'these are looking fantastic' but still used the opportunity to challenge their thinking further 'You've all started doing your drawings, um and what, if it is not turning out exactly how you'd like it to go at this stage, then use that as your rough sheet and then move on to do it on a better sheet as you go along' which was fairly typical of this teachers interactions

with the group. She was very pleased with what they were doing but she never missed an opportunity to challenge them to improve their work even further.

Having completed the introduction to the lesson the teacher asked the class to gather around one table where she proceeded to generate and develop her own idea in front of the group. During this part of the lesson the teacher took the time to explain and exemplify how to make the design sheet really effective with comments such as 'We've got details of what is happening in here, so what you need to do is get yourself a compass, draw a circle and then we're going to make it bigger' throughout the explanation the teacher gesticulated to make her point clear. She also referred back to the films in order to remind the group that they had to fully explain what smart or modern materials they were going to use and how they would work.

As the pupils continued to generate and develop their ideas, the teacher circulated interacting on a one to one basis with the pupils in order to challenge their thinking and help them to further improve their work. During these interactions some of the pupils were less than attentive which led the teacher to respond with comments such as 'That is very rude when I am trying to help you' which although a mild retort, served to regain the pupil's attention. At this point the teacher was very concerned about the overall presentation of the pupils' work and spent a lot of time pointing out how improvements could be made and what sort of graphics equipment could be used. The other thing which the teacher spent time doing, was encouraging pupils to come up with effective eye catching names for their products. In some cases the pupils actually helped each other and

then shared their thinking with the teacher for her approval for example 'Miss I have helped Hannah name hers. It is going to be called sleep tight baby cot' to which the teacher replied 'That's nice'. During this part of the lesson the teacher continued to test pupils' technical knowledge and to help them work out how their product would work with comments such as 'So what are we having on the screen? Do you remember we said before that we could have a bio-sensor? So you could wet your finger and then put it on that pad so that you can have a sensor' to which the pupils replied 'But you would need to programme it' and the teacher said 'Yes you can do that however you want' thus handing the thinking back to the pupil.

At the end of the lesson the teacher brought all of the work together on one table and invited the pupils to study each others' work. This gave them the chance to study what everyone else had done and to see if there were any techniques that they could add to there own work in order to improve it. She also referred back to the work that she had shown the pupils produced by previous classes, highlighting the fact that the current groups work was just as good. This was a great compliment to the group as their work was being compared to that of some of the most academically able pupils in the previous year group.

4.5.20 Analysis of Emergent categories in lessons 15 and 16

When analysing the video data for lessons 15 and 16, the transcripts of which are included in appendix 4P, it is interesting to note that the teacher began by working with the pupils in order to co-construct a list of things that should be on the A3 design sheet.

Through this process the group managed to construct a detailed list of requirements which were written on the board and could be referred to when required.

The teacher then drew the pupils' attention to the design sheet that she had placed on the board. This is the sheet that she had started working on during the last lesson and had completed in order to show the group. The teacher then took the opportunity to talk through what she thought of the design sheet by saying 'How do you think that works? .....Everything that you've mentioned are the things that I thought you should put on there as well. So, something nice, bright and catchy but something that's well presented' This explanation served to reinforce the joint thinking that the pupils had done in the production of the list that they had produced.

Next the pupils returned to their tables in order to complete their design sheets. At this point the pupils studied the work they were producing and some decided that it could be improved. At this point the teacher was very keen to ensure that the pupils referred to appropriate technology when explaining how their product works. In support of this interaction the teacher referred to materials covered by the films that the pupils had watched for example 'so we've got things like shape memory metal which will change shape so you can have it there' The teacher also made sure that the pupils were using appropriate graphics materials for their work so that they could achieve the highest possible results and made a point of praising the work that the pupils were producing. She was also very keen to make the pupils think about the overall presentation of their work

with comments such as 'So think about planning it out. Where might you put things? So you could keep this like this and then put that there'.

It was interesting to note that the pupils also talked to each other about issues related to the overall quality of their work for example 'how do those colours look now?' illustrating that the teacher was not the only form of advice available in the room. During this part of the lesson the teacher interacted with all of the pupils on a one to one basis in turn ensuring that they were all challenged to improve the quality of their work by including all necessary information. The pupils were also seen sharing ideas with each other for example 'Look do you like my wheels?' and giving constructive feedback such as 'If it puffs up into a bubble wouldn't it be dangerous' to which the other pupil replied 'No it would stop you getting hurt and it wouldn't blow up that big, just big enough to protect you'. During this part of the lesson some pupils were keen to start producing their presentation on the computers but were not allowed to do so until they had completed their design sheets. In one case when a pupil was not listening to the teacher, another pupil intervened by saying 'look what you do is a title, really big and then colour it in, then you will be allowed to go on the computer' to which the other pupil replied 'but I have a title' and the first pupil said 'yes but it needs to be gooder. So get it sorted out' which led to the first pupil doing as he was told in order to pursue his goal of getting onto the computer as soon as possible.

As the class were fortunate enough to have a laptop computer and projector in the room, the teacher was able to support some pupils by projecting images of the products they

were designing onto the board for example motorbikes so that they could use this as visual stimulus. This approach helped to improve the overall quality of the design work. The teacher also used a number of interactions which stressed graphical techniques to pupils which would help them to improve the overall quality of their work for example 'Right what you need to do is put this tracing paper over here and copy this through. Then we can present it more like the one on the board. OK'. The teacher also gesticulated and used praise a great deal in order to make her point which seemed to help the pupils to understand.

During the plenary the teacher got the group to gather around one table with their work in front of them. She began by saying 'Okay. I think what you can see from all of this is the designs that everybody have taken away from what we were doing on the board' which served to link the current work to the pupils' previous learning experiences. She then went on to ask the pupils to explain which designs they liked the most and why by saying 'Matthew, why do you like this one? Shhh' to which the pupil replied 'Stands out, colourful' The teacher ended the discussion by saying that she wanted the group to take away what worked and what did not so that they could further improve their work during the next lesson.

4.6 Discussion

In answering the question: **What are the features of the classroom interactions that support pupils' design activity?** The use of the classroom interaction data analysis grid facilitated fine grained analysis based on three analytical categories drawn from the

literature. These consist of: (a) **design decisions** (Barlex, 2005), (b) **Learning conversations** (Corden 2001; Coultas, 2007; Hamilton, 2003; Kumpulainen & Wray 2002; Wegeriff and Mercer 2000) and (c) **Scaffolding and Mediation** (Schaffer, 1996; Tharp and Gallimore, 1988). In addition to these categories there were nine emergent categories namely teacher gesticulation; the use of visual stimulus in the form of films and laminates; interaction to modify poor behaviour; the use of existing products to prompt discussion; the use of appropriate graphical techniques; the use of other pupils work; the use of the teacher's work and pupil gesticulation drawn from the data. In analysing the data against these categories it has been possible to ascertain the importance of them in the features of classroom interaction that support pupils' design activity.

4.6.1 Design Decisions as a feature of the classroom interactions that support pupil's design activity

When interrogating the data in terms of the design decisions made, it is clear that the approach adopted by the teacher governs whether the pupils are able to make design decisions or not. This finding is in keeping with those of a number of researchers in the field (Davies, 2002; Murphy, 2003; Rutland, 2004; Hardy, 2004 and Balchin, 2005) all of whom found that 'the pedagogic stance adopted by teacher either supports or restricts creative dialogue depending on its nature' as evidenced through the outcomes across a range of contexts, some of which enabled the development of creative outcomes and others which did not. For example when the teacher was explaining or directing, the pupils were required to listen but as soon as she allowed them to generate and develop their design ideas, either collaboratively as a mindmap or on their own as a final design

sheet, the design decisions began to flow. It is important to view this in light of the hegemonic approach (Lawson, 2004) often taken within Design and Technology departments where pupils are given a pre-defined design brief and expected to make the same thing as everyone else in the group. This approach prevents the pupils from making design decisions as the teacher has already made them. This approach, although it could be argued necessary for some units can make it difficult for pupils to engage with tasks because they lack ownership. This has been described in the field as 'fixation' (Cross, 2006; Nicholl, 2008) a term derived from cognitive psychology which refers to pupils being forced to follow what Nicholl, (2008) refers to as 'the line of least resistance' rather than a creative path when designing and making products which has been found to be counter productive to pupil engagement (Nicholl, 2008).

Throughout the generation and development of the design ideas during this study, the teacher modelled how to make a number of design decisions starting by insisting that the pupils design for a market and to meet a pre-defined need. A number of authors (Mercer, 1995; Wegeriff & Mercer, 2000; Corden, 2001; Kumpulainen & Wray, 2002; and Coultas, 2007) site the use of questioning as a vital component of the interactive learning experience. Throughout the lessons studied, the teacher showed an excellent use of questioning. In one example drawn from transcript 4B 'think about maybe where a baby goes to sleep, there's a lot of things with cot deaths. How can maybe something with smart fabric help with cot death? What do babies have in their room when they go to sleep, so that parents can keep an eye on them?' The pupils replied that often infants have baby monitors. The teacher continued 'exactly, so they also have the little speakers, so

could that be put into something else? Could it go into the bed somewhere, so that the speaker is actually a lot closer...' This dialogue shows the teacher co-constructing conceptual, technical and safety related design decisions with the group in a way that challenged them to think about the problem. The dialogue served to model the fact that these design decisions are linked and that as Barlex (2005) points out 'changes in one decision have a knock on affect on another'

Once the pupils returned to their seats it was interesting to note that they started sharing their designerly thinking with their peers unprompted. One pupil in transcript 4B said 'I might do a TV screen which you put across there (she gesticulates across her stomach) so that you can see the baby on it. Shall I do that?' Through this dialogue she shares her designerly thinking but goes on to seek the approval of her peers. In this one sentence she is beginning to make conceptual, technical and aesthetic design decisions whilst interacting with peers. Hennessy and Murphy (1999) in their research into collaborative problem solving point out that they 'believe that through discourse design ideas, solutions, plans and decisions are made explicit and visible; discourse also progresses thinking and is central to the process of knowledge construction as ideas are shared and assessed, feedback is received and interpreted, emerging problems are solved and joint decisions are taken'. This is related to Vygotsky's proposition of a continuous process of movement back and forth between word and thought. In the case of this unit of work, interaction and collaboration is encouraged on a whole class, pupil/teacher and pupil/pupil basis, making this a very powerful learning experience.

Once every pupil was settled, the teacher moved around the room engaging in one to one interaction. She used questioning extensively to take a pupil's idea and to challenge them to think about important design decisions they had yet to make. This interaction enabled the teacher to differentiate which is very important in this sort of learning, some pupils need a lot of prompting whilst others simply need to be challenged to ensure that they make all of the necessary design decisions about the product that they are designing. The interactions were so successful because 'the teacher intervened in a way that enabled the pupils to retain ownership of both process and task' (Hamilton, 2007).

One of the plenary sessions involved pupils explaining to the whole class what they were doing. One pupil in transcript 4B said 'I am doing a coat for a horse. When it is cold it warms it up. If it is hot, it cools it down' which illustrated that the pupils had begun to make a number of design decisions. She had identified the type of product thus making conceptual design decisions, she had begun to work out what the product would do by making technical design decisions and she decided that the product was for a horse thus she has made marketing design decisions. This whole class presentation of ideas is an important feature of the pedagogy adopted by the teacher. Pupils are expected to think carefully about the design decisions they are making and they must be able to articulate these to the rest of the class. This ensures that the pupils pay attention and are able to present their ideas effectively. Hoyles et al. (1991) building on Vygotsky's theory propose that 'a more explicit, organised, distanced kind of understanding is developed through having to explain one's ideas to a co-learner' as is the case in this study.

Another key feature of the sequence of lessons is that the learning flows. The teacher makes good use of assessment for learning, (Black et al, 2002) in order to establish what pupils know and understand in each lesson and then uses effective questioning to build on this. Although in modelling how to produce a design sheet the teacher did not allow the pupils to make individual design decisions, the ongoing questioning enabled the group to make collective decisions about the product being developed. This served to ensure that the pupils realised that they were not only expected to produce quality drawings but that the designerly thinking and justification also had to be of a high standard. The idea of sharing expectations with pupils so that they know the quality of work required of them is also a key element of assessment for learning (Black et al, 2002).

Once the pupils were working at their tables there were a number of pupil/pupil interactions. In one example in transcript 4C pupil A asked pupils C and D 'Are either of you two good at drawing people'. In response to this pupil C replied to Pupil A, 'I will have a go'. Pupil C sought further clarification of pupil A's requirements and then spent a little time helping her to do a drawing of a person on her sheet. In this case the pupil is adopting the role of the expert and spends her time ensuring that her peer can develop the skills she needs to develop her designerly thinking. This way of working supports a social constructivist view of the co-construction of knowledge where the pupils work together to develop their skills and understanding. It also evidences what I would like to term the development of pupil A's 'zone of proximal designerly development' (Trebell, 2007) which resulted in pupil A commenting 'Oh so that is why my people never look right, because I always give them a circle head'. In future she will not use a circle head and her

people will look more realistic but had she not worked closely with pupil C her knowledge would not have been extended in this way.

In recapping on the last lesson outlined in transcript 4D with questions such as 'So Maxine, what needs to be on there?' and accepting responses such as 'what the product does, how the product works, who the product is aimed at and what the product will look like,' the teacher could be sure that the pupils knew that they had to share conceptual, technical, marketing and aesthetic design decisions (Barlex, 2005) through their design work. By showing them her finished piece she was able to reinforce their collaborative thinking as she had highlighted all of the same things. In showing the quality required of the final product she was also able to ensure that the pupils fully understood expectations.

When the pupils went back to their places the teacher began once again using prompts and questioning supported by praise to prompt their thinking for example, once again outlined in transcript 4D 'Good do not forget to put the boxes on so that you can explain all of this' and 'So think about planning it out. Where might you put things? So you could keep this like this and then put that there'. This approach prompted pupils to make a series of 'What if I did this' moves (Schön, 1987) as he or she considers possible decisions about a feature and its effects on decisions made or yet to be made about other features. This inter-connectedness reflects a constructivist reflection-in-action paradigm for the pupil, considering the process of designing as a reflective conversation with the situation (Dorst & Dijkhuis, 1995). This is a stark contrast to a pedagogy which sees the teacher sat at the front and all pupils working in silence at their places. The interactions

here clearly challenge the pupils' thinking constantly and help them to make a broad range of design decisions.

4.6.2 Learning Conversations as a feature of the classroom interactions that support pupils' design activity

The data were analysed with a view to ascertaining the features of the 'learning conversations' (Hamilton, 2003: 36) which facilitate the development of designerly activity in 'fledgling designers' (Trebell, 2007) in schools. Categories drawn from the literature on constructive dialogue which illuminates a number of talk functions that empower learners in their thinking and acting: speculating, explaining, elaborating, questioning, challenging, hypothesising, affirming, feedback, evaluating and reflecting (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) were utilised. Speculating, explaining, elaborating, questioning, affirming and feedback represent language functions, whereas challenging, hypothesising, evaluating and reflecting represent cognitive processing.

In studying the data in order to ascertain the features of the learning conversations which take place in the designerly context being studied, it is important to note that the first thing that is striking is the variety of talk functions which take place within each lesson. At key points during the lesson the teacher explains what is required of the pupils. When doing so she challenges them through questioning taking their ideas and building on them in order to scaffold their learning. In doing so, the teacher 'creates a comfortable and safe

environment for thinking .....where all ideas matter and where there is no right answer' (Hamilton, 2007).

Research shows that classroom activities that encourage greater independence, risk-taking and intrinsic motivation, empower pupils in their learning (Dweck, 1986; Shaughnessy, 1991; Wallace, 1996). Dialogue and conversational engagement is crucial to the creation of a participatory process, critical thinking and learner empowerment (Mercer, 2000; Shor, 1992). Throughout the study the teacher utilised a broad range of talk functions in order to facilitate the development of the pupils designerly thinking and acting. These included:

- 'speculating' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) as she studied the pupils design ideas and then started to think about what else they might include to make them more effective;
- 'explaining'(Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) as she made a point of clearly introducing each task so that the pupils understood what they had to do;
- 'elaborating' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) on points made either by herself or by the pupils in order to make them take their thinking further and deeper;
- 'questioning' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) in order to ensure that the pupils were engaged in the designerly thinking rather than having all of the answers given to them;

- 'challenging' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) usually through the nature of the questioning in order to make the pupils think more about what they were doing;
- 'hypothesising' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) to a lesser degree when trying to outline the function and nature of a product;
- 'affirming' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) as a means of accepting pupils ideas and showing they are valued;
- 'feedback' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) to ensure that the pupils knew all about their design idea, how effective it was and how it might be improved;
- 'evaluating' in order to make visible what she thought of each design idea and what criteria she was judging it against;
- 'reflecting' (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) where she modelled her ability to reflect on the development of a design idea as it developed.

In the following extract from transcript 4E where the teacher was collaboratively mindmapping different types of carrying devices, she utilised a number of talk functions. 'Okay, you've got your school section, because you're school pupils' she reflected and then elaborated by adding 'that's what you relate to more'. She went on to challenge them to 'think about other people's needs' and to affirm and elaborate by asking 'What

kind of people need rucksacks?' This brief outline of interactions shows the complexity and variety of interactions required to develop pupils' designerly thinking. This exemplifies a socio-cultural view of learning where 'children learn by interacting with people in their environment and in cooperation with peers' (Vygostsky, 1978: 90).

Another feature of the teacher/pupil interactions is her ability to reflect on the answers given before extending the pupils' thinking. In the view of Schön (1983) 'the effective teacher is a reflective practitioner who strives to provide a learning context that engages learners cognitively, emotionally and socially' as is the case with the design-without-make unit of work. One very important feature which I believe is the cornerstone of designerly conversations is the use of the design or sketch as the centrepiece of the conversation. This was certainly the case as the teacher modelled the production of design ideas talking through their development as she drew them on the board. It also served as a useful tool during one to one interactions where the design ideas became the centrepiece of a 'conversation with the materials of the situation' (Schön, 1983).

In the classroom being studied there has been a successful move from 'pedagogical dialogue' to 'dialogical pedagogy' (Skidmore, 2000: 283) where the emphasis is on exploratory and constructive talk.

Another key feature of the learning conversations was the teacher's ability to relate the discussion to the real world with examples like 'Um, and this kind of device um, is similar to the ball barrow designed by James Dyson who also did the dual cyclone' from

transcript 4E and 'Any of you have a paper round? Any problems with your paper bag? Is there anything you could use to make it better? Do you walk around or bring your bag? Do you have a bag over your shoulder?' also from transcript 4E. This stream of questions served to engage the pupils.

4.6.3 Scaffolding and Mediation as features of the classroom interactions that support pupils' design activity

There are a great number of different forms of adult mediation, from the adult's presence, which provides the child with a secure learning environment, to encouragement, challenge, and feedback (Schaffer, 1996). Tharp and Gallimore, (1988) wrote about such forms of teacher mediation as modelling, contingency management (praise and critique, feedback, and cognitive structuring).

Given the nature of the learning environment created in this study where understanding is believed to be constructed socially and culturally (Chaiklin, 2003; Dow, 2003; Lidz & Gindis, 2003; Hamilton, 2003; Karpov, 2003; Koutsides, 2002; Kozulin, 2003; Lave and Wenger, 1991; McMilan, 2004; Miller, 2003; Sliepard, 2000; Vygotsky, 1978; Wersch, 1991), and that learning experiences are designed to embody this belief, the lessons were rich in scaffolding and mediation.

Throughout the lessons observed there were three main types of interactions, these consisted of teacher/whole class, teacher/pupil and pupil/pupil.

The following is an example of a teacher/pupil interaction from transcript 4I where the teacher is explaining how she would develop the pupil's design further. 'I might do some detail on the side, this eventually could be string with a toggle that you could fasten something into, okay?' which evidences the use of a combination of modelling, presence, encouragement, challenge and critique to help pupils develop their designs further. An interesting feature of this interaction is that although the teacher gives her opinion she ensures that ownership of the work remains with the pupil (Hamilton, 2007). Another example occurred in transcript 4I when the teacher continued to circulate and interacted with the pupils critiquing their work whilst giving feedback and challenge for example 'Try and get it a lot bigger on this side, so...instead of it being that size, you need to...'

It is a common finding of research on collaborative learning, that children need help in order to interact successfully according to the conventions of working together (Bennett & Dunn, 1991; Cowie et al., 1994; Rogoff, 1994; Brown & Campione, 1994; Mercer, 1995; Rojas-Drummond et al., 1998). This was certainly the case in this study where the teacher took a leading role in teaching the pupils how to work collaboratively. As this was a low ability group, the teacher used cognitive structuring to break the learning up into manageable chunks and give positive feedback, encouragement and praise at regular intervals to encourage them to continue to contribute. Throughout whole class interactions, the teacher utilised modelling extensively in order to show pupils what was expected of them. She did this when mindmapping the types of bags, taking this even further for this group as they are of very low ability by asking them to hold their bags up and making a list of the different types available. This is similar to the ideas of a number

of researchers, including that of 'the zone of proximal development' (Vygotsky, 1978), 'scaffolding' (Wood, Bruner & Ross, 1976; Bruner, 1983) and 'guided participation' (Rogoff, 1990) which show that adults generally adjust their support to assist children, simplifying the task where necessary and taking over the more difficult parts. She also modelled the generation and development of design ideas for the four Rs of creativity and later when designing for the future. During this designerly modelling she made her thinking explicit by saying what she was thinking as she was drawing. This enabled the pupils to see how she was using material such as the laminates and how she was able to process this and turn it into a design idea.

Another really important part of the scaffolding and mediation that took place in these lessons was the teacher's use of questioning. Here is a sample of questions used taken straight from transcript 4I, 'P stands for what, Georgia?' In this case the question is closed and very straightforward simply prompting recall from another lesson. 'What other kinds of bags?' This question is more open and designed to make the pupils think and contribute which they did. 'When you go to the supermarket, what types of bags do you see?' This is closed prompting simple recall. 'Where's your pen?' This is directive as the teacher wants the pupil to do as he has been told. The next few questions also taken from transcript 4I were asked in quick succession and were designed to challenge the pupil to think about an existing product and the issues that arise from using it. 'Any problems with your paper bag?, Is there anything you could use to make it better? Do you walk around or bring your bag? Do you have a bag over your shoulder? What do you have?' In my view this exemplifies exactly the sort of questioning that teachers

should be using in order to get pupils to reflect on existing products. The quick fire questions exemplify a keen interest on the part of the teacher in the design of everyday objects and how they could be improved.

'Peers have a crucial role to play in the scaffolding of one another's learning. Group learning environments, if properly structured, (as in this case) encourage questioning, evaluating and constructive criticism, leading to a restructuring of knowledge and understanding' (Naylor & Cowie, 2000: 93). This was certainly the case in the learning environment studied where a great deal of pupil/pupil interaction took place and was noted to have a positive effect on peers. In the next example from transcript 4L two pupils are co-constructing knowledge by considering the benefits and issues related to a particular design idea. 'You could have a T-shirt, and trousers and that yeah, and it goes like that into a big bubble when you crash' to which the other pupil replied 'if it puffs up into a bubble wouldn't it be dangerous' and the first pupil added 'no it would stop you getting hurt and it wouldn't blow up that big, just big enough to protect you' which shows that the pupils were thinking seriously about the issues inherent in their design proposal.

4.6.4 Emergent Categories as features of the classroom interactions that support pupils' design activity

There are a number of emergent categories which have been derived from the data collected to support this study. These consist of teacher gesticulation – using body language to help make ones point, use of visual stimulus material – laminates, use of visual stimulus – films, interactions to modify pupils poor behaviour, making use of

existing products for example pupils school bags, use of graphics kit that is tracing paper, felt pens etc, exemplar material – showing examples of other pupils work, exemplar material – using the teachers own work to show the level required and pupil gesticulation – using body language to help make one's point.

Many of the emergent categories covered here resonate with key features highlighted by a number of researchers in the field (Rutland 2004; Hardy 2004 and Balchin 2005). These relate particularly to the use of stimulus material (Rutland, 2004; Balchin, 2005) in the form of laminates which were available in order to encourage the pupils to utilise 'conceptual combination', a creativity enabling technique discussed in a case study of professional designers by Nicholl et al (2008: 56) and films which were used to introduce the pupils to different forms of smart and modern materials. Both of these resources could be considered to provide the pupils with precedent (Lawson, 2004) which is a vital component of the professional designers' toolkit and one which they cannot do without. The collection and use of precedent starts at an early point in a designer's career but it seems fitting that it is the teacher's role in a classroom environment to provide this and then to train pupils to collect their own so that they can begin to draw on this in future design projects. The introduction of artefacts (Balchin, 2005) in the form of the pupils' school bags and designerly stories about products such as the ball barrow and De Vinci's helicopter were also key features and thus, emergent categories.

The importance of the use of gesticulation both by teachers and pupils has been a key feature highlighted in a number of studies of interaction and seen as a means of

presenting a richer picture of the social setting (Mercer, 1995; Wegeriff & Mercer, 2000; Corden, 2001; Kumpulainen & Wray, 2002; and Coultas, 2007). Kimbell and Stables (2007) reflecting on previous research noted the extent to which gesticulation was utilised in early years but declined as pupils got older. In the case of this study it appears that gesticulation is a vital tool to support designerly thinking and acting which suggests that an appropriate pedagogy supports and values this form of expression.

In addition to this and not mentioned by other researchers, I would like to raise the important role that equipment plays in the designerly process. Although it may seem obvious and perhaps that is why it has not been highlighted, teachers attempting to teach without appropriate technical resources are unlikely to be able to achieve creative outcomes. The other emergent categories which proved vital to pupils' progress were the use of exemplar work both in the form of work produced by the teacher as she modelled the designerly process verbally and physically in front of the children, and work produced by pupils of the same age, initially from previous year groups but as work progressed, from this group. This was vital as the pupils were able to see not only what an able group could achieve but also what the pupils in their class could achieve. It would appear that this challenged the group which led to the production of some excellent design work.

Research Question C

In order to answer the question: **What is the teacher's attitude to design-without-make?** Interview data from data set C collected one week after the design-without-make unit finished, will be presented, analysed and discussed.

4.7 Presentation of data

In order to establish the teacher's attitude to design-without-make a semi-structured interview with the teacher was undertaken within the week following the final lessons on the design-without-make unit. A sample of the questions asked and answers received are shown in Table 10. The transcript is included in appendix 5.

Table 10 Questions asked and answers given by the teacher.

Question	Teacher
Question 1 …….. Okay? Okay, so last year, you taught a design without make unit, to a year nine group, a group of year nine pupils. In what way was the make-up of this group different to the last year's group?	Um, this group was a lot less lower ability, um, and that's the main thing, really. [Laughing].
Prompt Question Okay. Excellent. Um, so, by that, can we assume that there are quite a few special needs children in there?	Um, out of 14 or 15, I think there's 12 special needs.
Question 2 Right. Thank you. What difference did this make to the way you approached	……. trying to make it a lot more visual for them, doing a lot more work with the board, um, trying to not give too much of examples, but really trying to put them in a

teaching the design without make unit?	position to be able to visualise things. So, putting them into situations, and then, what would they do in those situations? .....
Question 3 Okay. In this unit, the pupils designed, but did not make their products. ..... In what ways was the response of this group similar to, and different from that of the last year's group?	Um, I approached this one completely differently. .....Whereas, this time round, we did a little bit of the toolkit, but the pupils found that harder to grasp, and they...they couldn't see the point of it, which is why we moved on to doing the DVDs more quickly, ...Actually, I don't think, apart from the first couple of lessons, that they ever brought up making it again, especially when they got onto the presentations. They were just happy to be able to design their own things.
Question 4 Okay. Tell me about the way you used the films and brainstorming to st...um, to scaffold the generation of design ideas.	Um, we used the, um, technologies DVD, and we watched the clips. ... First of all, I gave them a little bit of an introduction, and I gave them some questions that they should look out for, to answer when watching the clips. .... we, kind of, built up the brainstorm, all the technologies, and the different keywords, which then they...they wrote down from the board for future use for their presentation.
Prompt Question Okay. So, they were very much able to use that collaborative brainstorm in their own work, to remember, and to pull their own ideas from it.	Yes. Yes.
Question 5 Okay. Tell me about the interactions between you and the pupils, and between pupil and pupil, that took place, that supported the development of their ideas.	Um, to help them develop their ideas, um, to something a little bit more out of the box, we...we revisited the PIES situation..... So, we ended up doing a really big brainstorm of...of all different types of users, and then all different types of products that they might want to use, and any problems that they might have, um, which they worked really, really well at. Um, and then, from that brainstorm, they all, kind of, picked an area which...which led them on to having really diverse, um, products. Pupil to pupil, um, I think they did work well, um, they were...they would sit happily next to each other, and discuss what they were doing.
Prompt Question Okay. And, what about	Um, well, just going round, um, and just trying to get

your one-to-one interaction with pupils?	them to think about how the technology works……Um, how…how is it going to function, how is the user going to be able to use it? …..
Prompt Question Okay. So, to what extent, um, would you say that you were valuing their idea and building on that, rather than trying to impose your own ideas?	No, no. It was all their ideas, where they came up with a couple of great ideas.
Question 6 Excellent. Um, tell me about the design ideas of the four purposefully sampled pupils.	Um, they were good ideas. Um, I think they came up with ingenious ones. Kristy's was the baby scan. Hannah's was baby something, so they all came up with complete different ones. ……..
Question 9 Okay. Last year, in answer to the question, did the pupils come to value the quality of the ideas as the outcome of this unit, you noted that they were impressed with the ideas, as most talked animatedly about what they were doing, and it allowed them to be quite free in their thoughts. To what extent is the attitude of this group similar to, and different from that of last year's group?	Um, I think they were quite similar, in that they all were very excited, um, to be doing their own ideas, instead of being told, this is the project, and you have to do something within that. ……..
Question 11 ….. Do you think that the unit led to an improvement of design skills for the pupils in this year's group? If so, please give some examples.	Um, it did lead to better designing, …..
Prompt Question So, they were more creative, their designing skills have improved?	Yes. And, their presentation skills as well, and working on A3. ……

4.8 Data Analysis

In order to answer the question: **What is the teacher's attitude to design-without-make?** The interview data was analysed.

The analysis of the teacher interview shows that the teacher was very aware of the difference in level of ability of the pupils who had just finished the unit and those who were involved in the pilot study. This led in her own words to her 'Um, making it, um, trying to make it a lot more visual for them, doing a lot more work with the board, um, trying to not give too much of examples, but really trying to put them in a position to be able to visualise things. So, putting them into situations, and then, what would they do in those situations? Rather than, um, rather than trying to just tell them to do things, so that they understood it a little bit more'

The teacher felt that the pupils responded well to the unit and that 'they were just happy to be able to design their own things'

When asked how she used the films to support the pupils developing understanding of smart and modern materials the teacher said 'First of all, I gave them a little bit of an introduction, and I gave them some questions that they should look out for, to answer when watching the clips. Um, and we watched it, um, watched a clip, and then went back over it, I realised after the first time that they couldn't listen to it and jot down information, or they just didn't know what to pick up. So, after that, I think it was then me going back to board, saying, what things might you have picked up? Because, they weren't actually writing anything down. And then, when people started answering, if I

started them off, and they would... If I gave them a picture in their head, say with the shape memory [unclear], and I'll say, what was the silver shirt, why were they showing that? And then, they'd remember, and then give me information in that way. Um, so we...we, kind of, built up the brainstorm, all the technologies, and the different keywords, which then they...they wrote down from the board for future use for their presentation'. This illustrates that the teacher was reflecting on the success of her approach all of the time and that it was often necessary to change what she was doing in order to make it more successful.

When asked about the pupil/teacher and pupil/pupil interactions within the class the teacher said 'Um, to help them develop their ideas, um, to something a little bit more out of the box, we...we revisited the PIES situation, and for them not to just think about themselves, and maybe to, you know, to think about other people in that kind of situation, and what products would be useful for them. So, we ended up doing a really big brainstorm of...of all different types of users, and then all different types of products that they might want to use, and any problems that they might have, um, which they worked really, really well at. Um, and then, from that brainstorm, they all, kind of, picked an area which...which led them on to having really diverse, um, products. Pupil to pupil, um, I think they did work well, um, they were...they would sit happily next to each other, and discuss what they were doing. Um, I mean, it wasn't all the time, but they were, kind of, walking around and saying, oh, what was that, and what was that? Um, some of the boys came up with similar things, but that was probably, obviously, more that they'd seen what somebody else was doing, and thought that that was a good idea, and were bouncing off

each other that way. And, even though they came up with quite similar areas, like lots of motorbike, um, assisted products, they didn't all design the same thing for the motorbike, so they kind of helped each other that way, but it was still quite... For those ones, they were quite more basic,' which clearly illustrates that the development of a collaborative brainstorm helped the pupils to generate really interesting ideas which they were then able to share and build upon with their peers within the class.

She was very impressed with the quality and creativity evident in the design ideas and talked at length about the work of the purposively sampled four stating that 'Um, I think they came up with ingenious ideas. Kirsty's was the baby scan. Hannah's was baby something, so they all came up with completely different ones. Um, John's was to do with sport, and so was Steven's, but one was badminton, one was football. Um, they were...um, they were thought out well, I think the girls managed better than the two boys. Um...but I think because of the user group they went for, it was a little bit easier, than where it was, kind of, basing it on what they like to do. When they based it on something they like to do, they omitted a lot of information, because they just immediately thought, probably, that people would know what they were on about, rather than using something different.' The teacher continued by explaining how the ideas were of a much higher level of sophistication than would have been possible if they were required to make the product 'If they had to make the product that they'd designed this time round, a lot of them...a lot of them would have said, I want to do this, but I can't make it, so therefore, I probably won't. I'll sit here and I'll do nothing, because, to them,

it would have been a mountain they couldn't climb. And, I think a lot of them would have just given up, or designed something extremely simple'.

The teacher was unequivocal in her support of the process of design-without-make and clearly expressed the value of pupils presenting their ideas to each other. However, she did note that because of the low level of maturity within the group they found it difficult to concentrate when the class were presenting their work to each other which she found quite frustrating. She felt that the pupils '.... were very excited, um, to be doing their own ideas, instead of being told, this is the project, and you have to do something within that. Because, the response [unclear], we make it, and it was, are we coming up with the right designs, which was nice, and I think they, kind of, thought they were probably having a...an easy ride, because they were allowed to design what they wanted, rather than being told, you have to do this. And, I don't think they actually realised the creative extent to which they'd taken, you know, used everything within the lesson. I think they thought they were just having a free drawing lesson, but they didn't realise they were actually using everything that they've been learning, all the PIES and all the...the new technologies, which they were...they were all using'

The teacher also felt that the pupils were not alienated from the curriculum through the lack of opportunity to make as 'they came up with fantastic ideas. The ideas were better than last year, and they were much better thought about. Um, and they were wacky ideas, but they were also quite realistically based, as well. You know, having a baby scanner

that's portable, and it...you know, it does seem pretty far out, but there are things available like that, and it's nice that a 13 or 14 year old could think like that. Um...'

Discussion

In answering the question: **What is the teacher's attitude to design-without-make?** Analysis of the teacher interview transcripts show that the teacher thoroughly enjoyed teaching this unit. It is important to note that she trained as a product designer and is used to working in a collaborative environment which is why she was able to ensure optimal pre-conditions for collaboration (Murphy and Hennessey, 1999). Note, however, that this teacher when asked about pupils' response to design-without-make said, 'If anything it was hardest for some teachers to understand this concept'. The dominant pedagogy in design and technology is hegemonic (McCormick & Davidson, 1996) so a serious issue for the extension of this approach to a wider range of teachers is the extent to which those teachers can adapt their pedagogy to that required by the design-without-make approach, to developing designing skills.

Research Question D

In order to answer the question: **What is the pupils' attitude to design-without-make?** Interview data from data set D collected one week after the design-without-make unit finished will be presented, analysed and discussed.

Presentation of data

In order to establish the pupils' attitude to design-without-make, semi-structured interviews with the four purposively sampled pupils were undertaken within the week following the final lessons on the design-without-make unit. A sample of the questions asked and answers received are shown in Table 11. The rest of the interview data for the pupils is included in appendix 5.

Table 11 An example of the questions asked and the answers given by one of the purposively sampled pupils.

Question	Pupil A – Kirsty
Question 1 In this unit you designed a product but you did not make it. Tell me what you think about this?	Well, it was okay. But, I like making stuff, but I really enjoyed doing it, because we still got to, like not, kind of, make stuff, but we still got to make a project on it, and had to show it to the class. And, we've never done that before, so it's a new experience.
Prompt question What would normally happen?	Because, like, we'd all follow the teacher, and... But, we would get to go off, and do our ideas, but we got to work on our own as well, so that's all right, to do it as well.
Question 2 Okay. Brilliant, thank you. Um, in order to help you to design for the future, your teacher showed you a	I found it useful, because you could get different ideas, because most people... Some did T shirts, and everything, so they got ideas from the film as well, to help you get an idea of what to do, so that was quite

number of films about smart and modern materials, and carried out a collaborative brainstorm, that was a group brainstorm, in order to generate design ideas. Explain how useful you found this process.	good, as well.
Prompt question Okay. So, the films were quite inspiring, in the first place...	Yeah.
Question 3 Yeah, his seemed very good. Um, when you were designing for the future, you interacted with others in the class in a number of ways. You discussed your ideas with the people on your table, you discussed your ideas with your teachers, and you were involved in peer review sessions, where the whole class studied each other's design sheets. How useful did you find these? I'm going to ask you them one at a time, okay? So, how useful did you find it, discussing your ideas with people on your table?	Yeah, because I had other people working with me, so I could get ideas to help get, like, colours and everything, into my presentation. So, that's a good [overtalking].
Prompt question Okay. So would you say, on that little table, you asked each other a lot of questions?	Yes.
Question 4 Absolutely. Good, good. Right, tell me about the product that you designed for the future, as part of this unit of work.	I done [sic] a scan the baby, and it was a box that you could put onto your stomach, and you could see your baby if you were pregnant. And, you'd like...you can take pictures, and take videos and everything, on it.

Prompt question Okay. And, where was that to be used?	You could use it at home, so...because people didn't like driving, if they were pregnant, in case they had a crash and lost their baby. So, it was an easier way to have it at home...to do it at home, and everything.
Question 5 So, yeah, sounds really interesting. And, what did you think of your idea?	I, myself, would think it was quite good, because I haven't heard of anything like that before. And, um, and...and you wouldn't get a lot of queues at the hospital, as well, so you won't have to wait around all the time. Right, so I thought it was quite a good idea, as well.
Question 6 Okay. How is...? Explain how the need to make your product would have affected your design work. If you actually had to make that, what difference would that have made?	I think it would have, kind of, made it a bit harder, because, like, I'd have to get all the technology in it. So, it'd be quite hard to make...
Prompt question Hard, or impossible?	I think it... I don't know, really. I think it wouldn't be impossible, because I think you could actually make it. But, it would be quite hard to make.
Question 7 Okay. At the end of the project, you presented your ideas to the rest of the class. What did you learn from this experience?	It is nerve-wracking, because, like, you're doing it in front of the whole class, so it's quite nerve-wracking as well.
Prompt question Okay. What else did you learn?	Um... Well, it was quite nerve-wracking, because you had to, like tell everyone the whole project instead of just picking little bits out, so I found it was... it was hard, but I think it's all right.
Question 8 But yours was very clear. Having completed the unit of work, what do you think you learnt from the unit?	I learnt to present my work better, as well, and to look at, like taking things from the past into the future, as well.

Prompt question Excellent, and what would you say you learnt from the films?	I learnt from the films, like it was very useful, because you could get ideas from the films to put into your work, as well, and how the layout of the film went, so you could put it into like a still image on your screen [?].
Question 9 Yeah, so lots about that. Did you come to value the quality of the design idea as, as the outcome of the unit? So what you actually designed on the sheets, and what you presented, were you proud of what you did?	Yeah, I was quite proud of my work, because like, I've never done anything quite good like that, because some of my work doesn't turn out right. So I thought it was quite a... um, experience to get it right this time. [Laugh]
Question 10 Good. Does this process run the risk of alienating pupils from the curriculum, because you cannot make the product?	No, I think it's, it's a different experience, because we all usually make something at the end of our projects, but um, I think this one was quite good, because you can actually... you've actually made something, really, because you've put it onto a bit of paper. But like, you're presentating [?] out to the things, because... the class, because sometimes you don't get to do that, like stand up and talk about your work and how... the procedure you went through to get to it, like that stage. So usually you just show your work and you're done, but I think it was a better idea for people to actually listen to each other.
Prompt question Excellent, so you would say, with this unit you've learnt a lot of new skills?	Yeah.
Question 11 Um, did this unit enable you to improve the quality of your designing skills?	I think my designing skills were quite... well, they were good at some stages, in some stages, because like, you had to draw different ideas. But I can't draw, [laugh] so, um, I found it quite hard, but then it got easier as I went through it and actually found my one project I wanted to do, so I just stuck to that project and stayed on that.

Question 12 Okay. This unit of work consisted of the completion of a number of toolkit activities, followed by designing for the future, using smart and modern materials. Can you tell me, in what way the completion of the toolkit activities prepared you to design for the future? So the toolkit things were things like the PIES, yeah, physical, intellectual, emotional, social.	Yeah.
Prompt question And, um, things like that, so how did that help you?	I thought that was quite good, because we did, like bus shelters, so we could get ideas of how people feel when they're standing at a bus shelter, and like, not just straight seats, but you put like a circle of seats, so they could all sit round and talk to each other, to get to know each other more. So I... and I did like, the PIE thing on my scanning the baby, with how people would like to see the screen, and everything, so I found it easier.

4.11 Data Analysis

In order to answer the question: **What is the pupil's attitude to design-without-make?**

The interview data was analysed.

Analysis of the pupil interviews shows that they were very positive about the concept of design-without-make prompting comments such as 'Yes, it was fun' and 'Um, I liked doing it because it's different to other things that you do, and you can learn more stuff .....' They were particular keen to explain that they enjoyed being allowed to design

their own things with one pupil noting 'everyone else got to do their own thing, so, like...and the whole class enjoyed it, I think, as well'.

When asked how useful the production of the collaborative brainstorm was the pupils said 'I found it useful, because you could get different ideas, because most people... Some did T shirts, and everything, so they got ideas from the film as well, to help you get an idea of what to do, so that was quite good, as well'.

As this was a study of classroom interaction I also asked the pupils the following question 'when you were designing for the future, you interacted with others in the class in a number of ways. You discussed your ideas with the people on your table, you discussed your ideas with your teachers, and you were involved in peer review sessions, where the whole class studied each other's design sheets. How useful did you find these?' To which the pupils replied 'because I had other people working with me, so I could get ideas to help get, like, colours and everything, into my presentation. So, that was good' and 'Yes, we ah, it is very useful, because we found out others ideas, and we helped each other'. They agreed that they gained useful help from their peers, their teacher and through the peer review sessions all of which helped them to develop their design ideas.

The pupils were very keen to share their design ideas, prompting detailed feedback such as 'I done a scan the baby, and it was a box that you could put onto your stomach, and you could see your baby if you were pregnant. And, you'd like...you can take pictures, and take videos and everything, on it' and 'I designed a badminton racquet, which has got

a screen on it, and sensors on the string, which then tells you if your shot was a good bat, good or bad shot, and how many times you've hit the shuttlecock'. They were clearly proud of their design ideas prompting comments such as 'I, myself, would think it was quite good, because I haven't heard of anything like that before. And, um, and...and you wouldn't get a lot of queues at the hospital, as well, so you won't have to wait around all the time. Right, so I thought it was quite a good idea, as well' and 'I thought it was really good, so I was really pleased with myself that I had actually done something a bit different'

They all agreed that the need to make would have led to simplification of the design and that the unit taught them to design to meet a given need and for use by a clearly defined target market.

The pupils agreed that they would recommend design-without-make as a way to enhance the quality and creativity of ideas produced by pupils and one pupil commented that it worked effectively 'because you have more time so you put more thought into it'. They agreed that they came to value the design work as a product in itself and interestingly did not feel that the process alienated them from the curriculum with one pupil commenting that 'you can design it however you wanted to design it, put anything you wanted on there, really'.

In addition they felt that the approach enabled them to improve their designing skills and one pupil commented that, 'Ah, yes, I'll say, yes, because it made me get more ah,

informational things, and I now know I'm doing it properly now, if I have to ever do it again'.

4.12 Discussion

In answering the question: **What is the pupil's attitude to design-without-make?** Analysis of the interview transcripts shows that the pupils valued the opportunity to interact with both their peers and their teacher. This finding is in line with those of a number of researchers who have begun to focus on the study of a social constructivist approach to pedagogy Barlex and Welch (2007); Hamilton (2003); Hamilton (2004); Hamilton (2007); Hennessy & Murphy (1999) and Murphy & Hennessy (2001).

The pupils also found the opportunity to design-without-making what they had designed a liberating experience as it gave them ownership of their work. This echoes the findings of Balchin (2005); Dineen & Collins (2005); Rutland (2004) and Hardy (2004) who outlined the importance of the nature of the task in ensuring pupil engagement and opportunities for the production of creative outcomes.

Chapter 5

Conclusion

Four research questions drove this study: (a) What sort of designing do pupils do when they design without having to make what they have designed? (b) What are the features of the classroom interactions that support pupil's design activity? (c) What is the teachers' attitude to design-without-make? (d) What is the pupils' attitude to design-without-make?

In response to the first question, the pupils in this study revealed that their designing is highly iterative, creative, involves making a wide range of design decisions and revealed understanding of technological concepts.

In response to the second question the features of the classroom interactions that support pupil's design activity are many and varied. A number of the features have emerged as themes from the literature and have been tested during this study in order to identify their significance in the development of pupil's designerly activity. These consist of: a) Design decisions - Barlex, (2005); b) Learning conversations drawn from literature on constructive dialogue - (Kumpulainen & Wray 2002; Corden 2001; Wegeriff and Mercer 2000; Coultas, 2007) and c) Scaffolding and Mediation - (Schaffer, 1996; Tharp and Gallimore, 1988).

It has also been possible to identify a number of emergent categories from the data namely: teacher gesticulation, the use of visual stimulus such as laminates; the use of

visual stimulus such as film; interactions related to managing pupils' poor behaviour; making use of existing products; making graphics equipment available; showing examples of pupils design work; pupil gesticulation and the teacher exemplifying the generation and development of design ideas.

5.1 Design Decisions

When considering the importance of being able to make design decisions as a feature of effective classroom interaction during designerly activity, this study shows that it is essential that pupils are given an opportunity to make these decisions, as in this study, where the teacher prompted the pupils to explain: Who the product was for (marketing decisions); What the product does (conceptual decisions); How it works (technical decisions); What is it made from (material decisions); What the product looks like (aesthetic decisions) and How safety can be ensured (safety decisions). It is also clear that the pedagogic stance adopted by the teacher either facilitates designerly decision making or prevents it. This is an important challenge to existing prevailing pedagogy which largely dictates outcomes and prevents a wide range of designerly decision making. In conclusion enabling pupils to make a broad range of design decisions is an essential feature of the classroom interactions which support the development of designerly activity in 'fledgling designers' (Trebell, 2007).

5.2 Learning Conversations

The features of the 'learning conversations' (Hamilton, 2003) which facilitate the development of designerly activity, in 'fledgling designers' (Trebell, 2007), consist of a

5.3 Scaffolding and Mediation

When considering the importance of the use of different forms of scaffolding and mediation as a feature of classroom interaction during designerly activity, it is interesting to note that in this study the full range of scaffolding and mediation was used throughout the unit. The adult's presence was highly noticeable as she supported both whole class and one to one interactions, she studied all of the pupils work and in each case praised their efforts and gave them feedback which included challenge and critique in order to enable them to improve their work further. In whole class instruction, the teacher used cognitive structuring in order to structure the pupils thinking through a task and modelling in order to illustrate how it could be done.

This broad range of scaffolding and mediation would not have been evident had the teacher set a closed brief to which most of the answers were already defined. The richness of the interactions is inherent in the wide range of products being designed at the same time in one class which necessitated the teacher interacting with pupils on a one to one basis to ensure that they were successful. However, it should be noted that the ability of the teacher to support the development of multiple design solutions was a testament to her confidence and knowledge in the domain.

5.4 Emergent Categories

When considering the importance of a range of emergent categories as a feature of effective classroom interaction during designerly activity, it is interesting that all of those identified were well used throughout the study and proved to be vital in supporting the

production of effective design work. Gesticulation by both teacher and pupils proved to be a means of communication which made up for some of the lack of skill currently available in the pupils' designing repertoire. The visual stimulus in the form of both film and laminates served to inspire the pupils and to enable them to understand smart and modern materials. The use of existing products enabled the teacher to put a concrete form to some of her thinking which helped pupils to understand requirements. In the case of the graphics equipment it proved vital that the teacher understood about such equipment and was able to provide relevant items for the pupils as required. This included tracing paper, stencils etc. All of which helped the pupils to improve the overall quality of their design work. The last form of emergent category relates to interactions to do with managing behaviour which were well used during this study.

In summary the features of classroom interactions which support the development of designerly activity can be represented as a diamond (fig. 25) with each point of the diamond representing a set of interactions which if enabled during designerly activity, support the development of fledgling designers (Trebell, 2007). It is envisaged that these categories could be utilised in future studies of designerly activity both in order to support the framing of the study and as an analytical tool. The more categories that are studied, the more detailed the analysis will be leading to a deeper understanding of the designerly context being studied. Taken as a whole the use of the interaction analysis categories will provide a rich picture of the social setting in which designerly activity is taking place.

make what they had designed. It is important to note that this teacher is one whose approach to pedagogy is highly appropriate for design-without-make and that this may not be the case for other teachers.

In response to the fourth question, it is clear that the pupils enjoyed the design-without-make approach and valued their design ideas as an outcome in its own right. The pupils were not alienated by the design-without-make approach. Indeed the reverse is true. They valued the opportunity to design products in response to issues and situations which were personally relevant and meaningful.

It must be acknowledged that this study involved only one teacher working with a single class of nineteen low ability pupils. Hence it will be important for future work to explore the response of a larger number of teachers working with a wider range of ability in a number of different contexts. The teacher showed herself as particularly adept at managing collaborative learning, both within groups of pupils, and between herself and individual pupils. It will also be important to develop a number of intervention studies where the units of work have been designed to enable the features of classroom interaction during designerly activity to be utilised during design and make assignments where existing prevailing pedagogy is challenged and pupils are given greater autonomy in their decision making.

Given that there is some evidence that not all teachers can adopt the pedagogy required for the successful teaching of design-without-make it will be important to investigate models of professional development that enable teachers to modify their practice.

Impact on Professional Practice

It is my intention to ensure that this thesis has an impact on professional practice by turning the findings into a handbook of designerly activity which explores, through the use of images and text related to underpinning theoretical assumptions, ways in which designerly activity can be developed successfully in the mainstream classroom by practicing teachers.

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