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ORIGINAL PAPER

Perspectives on pupil creativity in design and technology in the lower secondary curriculum in England

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Abstract This paper is based on work carried out as part of a research study into the professional practices of secondary design and technology teachers in England. It focused on fostering creativity or teaching for creativity as defined by the Robinson Report (1999, All our futures: creativity, culture and education. London: Department for Education and Employment (DfEE)) for pupils aged 11–14 years. The overall research question that drove this study was ''to what extent can teachers influence the creativity of pupils aged 11–14 years in design and technology lessons?'' The paper provides the basis used to generate a unique theoretical three-feature model or framework that can be used to explore creativity within an educational context. The findings of three investigations in the study are presented in this paper. The first and second investigations looked at what could be learnt from the professional practices of art and design and design and technology teachers and the views of four 'expert' teachers known for their ability to develop the creative potential of their pupils. The data is discussed under emerging themes and it is used to inform specific criteria in the evolving theoretical three-feature model for creativity. The model is then used to analyse the data from the third classroom based investigation and the findings are discussed under the emerging themes to help identify the issues related to fostering creativity within the design and technology classroom. This paper discusses the implications of the research for classroom practice and suggests that, as creativity is a complex, multi-faceted concept and process, the theoretical three-feature model and related criteria evolved in the study provides a sound framework to explore creativity within an educational context. As a tool it helps identify examples of good practice and highlight areas that require further attention by teachers aiming to foster their pupils' creativity. It is suggested

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that design and technology teachers have lessons to learn from the practices of their art and design colleagues and 'expert' design and technology teachers. It is concluded that there is a need for greater understanding by teachers of their implicit theories regarding teaching, learning and creativity. A wider use could be made of the breadth of strategies outlined by the 'expert' teachers. This would help address the weakness identified in the school based study and strengthen classroom practice when teaching for creativity.

Keywords Design and technology · Teaching for creativity · Classroom observation · Art and design · 'Expert' teachers

Introduction

This paper is based on a research study exploring the professional practices of teachers with specific reference to fostering creativity in technology, or design and technology as it is known in the English classroom, in the lower secondary curriculum. It presents some of the findings from three sub research questions of a larger study looking at the research question of *'to what extent can teachers influence the creativity of pupils aged 11–14 years in design and technology lessons*?' An overall aim of the study was to develop a theoretical model, or framework, that could be used to collect and analyse data related to creativity to highlight examples of good classroom practice in design and technology and identify 'gaps' that should be addressed. The three sub-research questions of relevance and addressed in this paper are:

1. What can design and technology teachers learn about teaching for creativity from the practices of art and design and design and technology teachers?
2. What strategies can be used by design and technology teachers when teaching for creativity in the classroom?
3. What is the present situation in fostering creativity in the design and technology classroom for pupils aged 11–14 years?

Though the context of the research was in England the educational concepts and pedagogical issues addressed are rooted in international literature and are likely to have relevance for readers from a wider audience. A key premise was that teachers can impact to a greater or lesser degree on their pupils' creativity. This moves away from a traditionally held view that some pupils are creative and some are not. That genes and the biological make-up of a pupil are the key factors and there is nothing that a teacher, or school, can do to change this situation. It centres on the concept that the teacher is at the centre of a dynamic process and it is their 'personal constructs', a complex amalgam of their personal beliefs and past experiences that underpins their professional practices (Banks & Barlex, 1999; Banks et al., 2004).

The decision to focus on the lower secondary phase of school was based on the perception of the researchers that pupils' creativity in design and technology is a weakness at this important stage of their education. As a result pupils' work in design and technology tends to become more restricted and less 'original' as they move through secondary schooling. This observation is supported by classroom studies in the United States (Sternberg & Grigorenko, 1997), where it was found that as pupils progress through school they show less and less spontaneous creativity in their thinking. In England educational research has indicated discontinuity in the type of activities and the pupil's experience of design and technology between the

primary and lower secondary phases (Kimbell, Stables, & Green, 1995) with the introduction by the teacher of more closely structured teacher led curriculum activities.

A theoretical model for creativity

The term creativity is used to reflect a psychological view of creativity at a personal level in contrast to innovation as used in the world of business at an organisational level (Sternberg & Lubart, 1999). Views on differences between these terms vary. Kimbell (2002) in the field of education argued that creativity is one of the basic constituents of innovation and described innovation as 'applied creativity', whereas, Hargreaves (2000, p. 2) argued that 'you can have creativity without innovation but you cannot have innovation without creativity'. In the context of this educational study, it is acknowledged that creativity is an important element of innovation and that it can be developed initially in the design and technology classroom (Barlex, 2003a).

The expectation for creativity was implicit but not clear in the original National Curriculum Technology Orders in England (DES, 1990), lacking in the later Design and Technology Orders (DfE, 1995) before being reinforced in the latest Orders (DfEE and QCA, 1999). The 'importance of design and technology' statement expects pupils to 'learn to think and intervene creatively...become autonomous and creative problem solvers' (DfEE and QCA, 1999, p. 15), so highlighting creativity as an essential element of the design and technology curriculum. Despite this, some consider that creativity in actual classroom practice in England may be in crisis (Barlex, 2003a; Kimbell, 2000) and that recent pressures in education have 'contributed to the damping down of creative fire in design and technology' (Kimbell, 2000, p. 211). A theme that was developed by Barlex (2003a, p. 5), who noted that design and technology did not have a high priority in the Robinson Report, *All our futures: Creativity, culture and education* (DfEE, 1999), though it does acknowledgment the potential for creativity in designing.

It was the Robinson Report (DfEE, 1999) in England that made recommendations for a national strategy for creative and cultural education to ensure the development of young people's capacities for original ideas and action. It was argued that there is a shortage of teachers who aim to foster pupils' creativity because it is not easy to be such a teacher. This is because it involves discovery, risk taking, pushing limits, and taking steps into the unknown, an issue that has relevance and significance for other countries around the world. 'This is a serious business—dangerous business and when you challenge students (or pupils) to be creative, you lose control' (Torrance, 1995, p. 107). The Robinson Report (1999, p. 89) defined creative teaching in two ways, first 'teaching creatively' and second 'teaching for creativity'. Teaching creatively in the report is interpreted as when teachers use imaginative approaches to make learning more interesting, exciting and effective. This can be described as merely 'good practice', as the teacher are themselves creative and take the initiative to develop materials and approaches that interest and motivate pupils. Whereas, in teaching for creativity, the focus is on forms of teaching that are specifically intended to foster and enhance their pupils' creative thinking or behaviour. The focus of this research was clearly on teaching for creativity.

In the early stages of the research it was noted that despite support for the concept of fostering pupils' creativity there was very limited evidence of research in

secondary design and technology in England, or other countries, though educational writers had explored creativity as a domain free concept in the primary phase. An international literature review in the field of psychology was carried out to attempt to define creativity, though this proved to be a complex matter. A consensus was that 'big' creativity is when something of enduring value is developed that contributes to an existing field of knowledge and transforms it, whereas 'small creativity', though equally valuable gives a fresh and lively interpretation to an issue (Feldman, Csikszentmihalyi, & Gardner, 1994). In the context of education, including design and technology, most of the time the teacher will be teaching pupils for 'small' creativity, but this is perfectly valid and probably a pre-requisite for the pupils to eventually attain 'big' creativity later in life. The Robinson Report (DfEE, 1999, p. 29) defined creativity an 'imaginative activities fashioned so as to produce outcomes that are original and of value'.

During the process of developing the model or framework to investigate creativity a number of models for creativity were explored. However, the views of Amabile (1983, 1996) were considered to be the ones most relevant for education and this research. Her conceptual definition for creativity included two essential elements. 'A product or a response will be judged as creative to the extent that (a) it is both a novel and appropriate, useful, correct or valuable response to the task at hand, and (b) the task is heuristic rather than algorithmic' (Amabile, 1996, p. 35). Specifically, she highlighted the impact of specific social factors and intrinsic motivation on creativity and described creativity as the confluence of intrinsic, or self, motivation, domain-relevant knowledge and abilities, and creativity-relevant skills. The creativity-relevant skills relate to strategies and approaches that the teacher teaches pupils so that they have some tools for being creative. Amabile (1989) argued that our western culture places great emphasis on talent, skill and hard work yet they make up only up two-thirds of the creativity formula with intrinsic motivation as the remaining third. Thus, when helping a pupil to become their most creative self, it is not enough to train them in skills, give them opportunities to develop their talents or develop good work habits. There is a need to help them identify the places where their interests and skills overlap, which she calls the 'creativity intersection'. She argued that it is at the intersection where pupils' domain skills and creative-thinking skills overlap with their intrinsic interests that the pupil is most likely to be creative.

Before becoming aware of Amabile's work the perceived view of the researchers was that creativity depended on a person's characteristics and cognitive abilities (Gardner, 1993, 1999), as pre-determined factors over which teachers have limited influences. On the other hand, Amabile argued that the supportive social environment, or the classroom in the context of education, is a key factor in ensuring that a person's creativity potential is realised. This is a factor that, unlike the characteristics of a pupil, can be influenced by the teacher through the organisation and management of the classroom and the teaching strategies used.

The framework for a theoretical three-feature model for creativity generated in the research is intended to be used specifically in an educational context. A multi-component approach was developed as it emphasises the importance of the environment as highlighted by Amabile (1983, 1989, 1996) and highlighted that creativity only occurs when the three features converge (Csikszentmihalyi, 1994, 1999; Feldman et al., 1994). The first feature relates to factors in a specific subject domain such as design and technology, but the intention is that the other two features are

generic and could be used to explore creativity within other domain areas of the school curriculum. The model consists of three essential features:

1. *Domain relevant features*—a set of practices associated with an area of knowledge, for example design and technology or other subjects such as science, mathematics
2. *Process-relevant features*—influencing, controlling the direction and progress of the creative process.
3. *Social, environmental features*—macro/micro environmental, social and cultural issues (Fig. 1).

The role of the teacher and their impact on fostering pupil's creativity is central in that they are the 'gate keepers' who sanction what should be included in the subject domain (Csikszentmihalyi, 1996, 1999), for example making judgements about pupils' work, their portfolios and products. However, of crucial importance for this research are the teaching strategies which influence the procedures and processes followed by the pupils. In addition, the teachers should manage and organise their classroom to ensure that the social and cultural environment is conducive to creative activity. If this model was used to map data related to teaching for creativity within other domains or curriculum areas there would be a need to develop specific domain criteria for creativity. In the domain of design and technology the following four criteria for creativity were identified:

- *The concept or idea*—has the designer proposed a concept that is original, novel, feasible, useful, will function etc?
- *Aesthetic creativity*—has the designer made proposals about those features of the product that will appeal to the senses, for example, sight, hearing, touch, taste and smell? Is there something about these proposals that is particularly novel and attractive?
- *Technical creativity*—has the designer made proposals about the way the product will work and the nature of the components and materials required to achieve this? Is there something about these proposals that is novel or elegant?

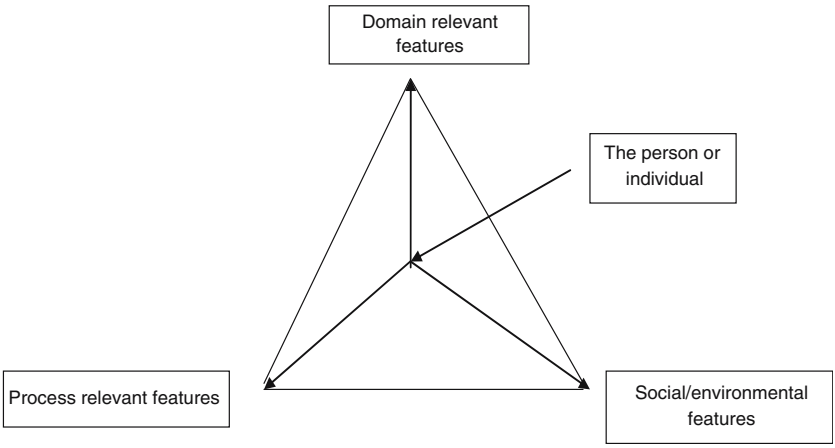

Fig. 1 Three-feature model for creativity

- *Constructional creativity*—has the designer made proposals about the way the product will be constructed and the tools and processes needed to achieve this? Is there something about these proposals that is novel or original?

Methodology

Qualitative research methodology was used in the research because the data collected would be rich in descriptions of people, places and conversation and not easily handled by statistical procedures' (Bogdon & Biklen, 1992) and it was considered that this approach was more effective when considering subjective, inductive and speculative data (Burgess, 1985). This applies to a case study in which data has been acquired by sitting in a classroom making field notes and records of classroom activities or interviewing teachers and pupils. The research methodology included 'ethnographical' methodology involving the study of social organisations (Tesch, 1990) and participant observational techniques to acquire data in a real-life setting (LeCompe & Preisssle, 1993). The methodology is 'deductive' as it involved organising previously unordered or poorly understood fact(s) concerning creativity in design and technology for a better understanding (Burgess, 1985).

A series of 'sub' research questions were developed to explore the issues relevant to the key research question:

> To what extent can teachers foster creativity in design and technology classrooms?

The first 'sub' research question was 'What can design and technology teachers learn about teaching for creativity from the practices of art and design and design and technology teachers?' This sub-research question drove the first investigation and the intention was to identify ways in which design and technology teachers could learn from the practices of their art and design colleagues.

This investigation was part of the joint Nuffield Design and Technology and Qualifications and Curriculum Authority (QCA) Project, 'Creativity in Art and Design and Design and Technology' which took the opportunity to explore creativity in art and design and design and technology. In early 2000, twenty art and design and design and technology teachers for pupils aged 5–16 recommended for their interest in creativity by local education authorities in England were invited to a meeting by QCA and the Nuffield Curriculum Centre to discuss their work and develop a joint approach to their practices. In the Autumn of 2000 six art and design and four design and technology teachers used this approach to plan, teach, document and assess a unit of work for their pupils across the age range of 5–16 years. During November and December 2000 half-day visits by one of the researchers were made to three primary and three secondary schools for art and design and two primary and two secondary schools for design and technology to explore:

- The context of each of the schools
- Their perceptions of the place and role of the subject
- The project *teacher's approach* to the subject
- The *specific work* being done on creativity.

The data from the field research notes was analysed against a series of emerging themes.

The second sub-research question was *'What strategies can be used by design and technology teachers when teaching for creativity in the classroom?'* This was achieved through interviews with four 'expert' teachers known to value and foster originality and creativity in their pupil's work. They were Adam (product design); Bev (food technology); Clive (systems and control); Dawn (textiles technology). The 'expert' teachers were asked to focus on a unit of work they had taught in schools in the context of teaching for creativity. They were encouraged to talk about the way they had taught and explain why they had adopted particular ways of teaching. The data was taped, transcribed and mapped against the three-feature model and the findings presented under the emerging categories.

The data from the first and second investigations was used to develop and inform the specific criteria in the evolving theoretical three-feature model for creativity. The model was then used to map or analyse the data collected from the third classroom based case study before discussing the findings under the emerging themes, drawing some conclusions and highlighting the implications for classroom practice.

The third sub-research question was *'What is the present situation in fostering creativity in design and technology classroom for pupils aged 11–14 years'*. A school based case study, including classroom observation and interviews with teachers, was undertaken in an attempt to obtain in-depth data of teaching for creativity in typical design and technology lessons. An urban, mixed comprehensive school for pupils aged 11–16 years agreed to take part in the study. The research centred on a Year 8 mixed ability design and technology class with seventeen pupils, nine boys and eight girls, taught by two teachers in two of their design and technology focus areas, systems and control and food technology. A 'naturalistic', overt, semi- structured observational study (Cohen, Manion, & Morrison, 2001) was carried out to capture a 'snap shot' of the situation in typical design and technology classrooms. In naturalistic inquiry the 'human', or researcher in this situation, is the main form of data collection (Tesch, 1990) and is the *participant-as-observer*. The study ran over a six-month period from the initial contact with the school, pupils and teachers in the summer of 2001.

The first unit of work (a) 'The Grabber' observed in this study focused on systems and control over seven lessons. The pupils were asked to imagine that they were technologists working in a Mars bar factory and were in charge of the pneumatically driven chocolate processing machine. During the unit the pupils were required to design and make a 'grabber' based on mechanisms and pneumatics, new concepts for them, that could be used to recover mini Mars bar that fell off the moving belt without turning it off. They used at least two pneumatically controlled syringes to make a mechanism that could grab hold of and lift the bar. In lessons 1–5 the pupils modelled types of levers and pneumatic systems using syringes and tubing. In lessons 6 and 7 they designed, made and tested their own 'grabber'.

The second unit (b) 'Healthy Eating' focused on food technology and consisted of two parts. The first five lessons looked at 'The functions of ingredients, packaging and labelling' and included a wide range of practical activities and the second four lessons focused on designing and making a healthy lunch box. In this Year 8 unit the functions of food were new concepts and introduced words such as 'emulsification' when making mayonnaise and 'bulking' ingredients. The teacher covered new technical knowledge about the properties and functions of ingredients, nutrition,

packaging and environmental issues through a series of short tasks and practical activities. The practical food based activities were to develop the pupils' food preparation skills and they included a chilled dessert, a pasta sauce based product and a layered salad. In the second section of the unit pupils were expected to design and make a healthy lunch box using the knowledge and skills they had learnt.

Findings from the first investigation

Data from the first investigation exploring the practices of art and design and design and technology teachers was analysed against the emerging themes of ethos, or culture, of the school, activities, teacher support and constraints.

Ethos, or culture, of the school

Senior management in each of the schools visited stated clearly that they considered creativity to be an important aspect of the school's ethos or culture and this was reflected in the views and practices of the teachers. Creativity contributed to the ethos or culture of the schools visited in a number of different ways. In some it was explicitly referred to in development plans and school mission statements with an involvement in national creativity initiatives. Interviews with head teachers revealed that a majority saw support for creativity from senior staff as essential with positive links made between creativity and learning and concomitant dedication of both physical and human resources. There was a high profile for creative arts in the curriculum and external links with the local community, advisers, museums, art galleries and art colleges were cited as important.

Activities

In art and design both primary and secondary schools used 'themes' as a context to stimulate and motivate their pupils. This included projects based on open themes such as the style of an artist, architecture, a play, the seaside or historical events and people. This was not the situation for design and technology where projects in both phases were 'closed' and 'product' based, for example a 'pizza', a 'musical instrument', a 'novelty notebook' or a 'toy'. The pupils were not encouraged to investigate a context, explore design ideas and consider a range of common, but different outcomes. ''Closed activities' or focused practical tasks ensure that pupils learn and practice a base of knowledge, understanding and skills upon which they can draw in more open-ended designing and making activities. However, the use of restricted, narrow briefs did not offer pupils scope to use what they had learned through focused practical tasks to generate and develop their own ideas. In one secondary school the Year 9 design and technology design brief was particularly 'closed'—'toys on wheels', with little opportunity for making design decisions regarding the size of wheels, movement, materials or shape of the body. The only variation was in decoration.

Secondary and primary art and design teachers began projects with visual stimuli and required their pupils to carry out individual research to develop their thinking. These activities included making connections by exploring shapes, colour and

observing buildings and natural objects. The use of interesting and varied starting points and a wide range of stimuli, including visual, were not used by the design and technology teachers. Primary art and design and design and technology teachers were more likely to allow the children to experiment and work as a whole class or in groups. The range of types of activities was varied; they included discussion, school visits, visiting speakers, field trips, displays and school performances for parents. Primary design and technology teachers were more open to this approach than their secondary colleagues and allowed the children to investigate and generate their own ideas and make decisions as well as develop skills, knowledge and techniques.

Both primary and secondary art and design teachers were clear about the need to develop technical and aesthetic knowledge through colour, shape and form, techniques of shading, observational drawing and making 3D models. They encouraged pupils to make decisions and have 'thinking' time. Two secondary teachers commented on the time needed for technical 'construction' activities. In one secondary school it was noted that when an art and design teacher taught a design and technology project that the work was visually better, but that there was less quality in the finished technical aspects.

The secondary design and technology teachers emphasised developing technical and constructional creativity, the skills and knowledge required to 'make' something for a specific purpose and working as individuals. Finished quality and functionality were key issues rather than developing design ideas, learning about a range of materials and techniques and making design decisions. It was uncommon for secondary design and technology pupils to work in groups to stimulate thinking, explore materials, investigate, test, make models and develop ideas. One teacher had adapted her approach to include a 'see if it works' and encouraged experimenting with colour and materials. She commented that this approach took longer but that the work was 'far more imaginative and creative than in previous years'.

Teacher support

In both art and design and design and technology teachers commented that there was a minority of pupils who were self motivated to be creative and a majority who needed support and guidance from teachers. For the majority of pupils the role of the teacher was seen as crucial in creating a supportive atmosphere, where pupils developed knowledge, understanding and skills in materials and techniques and then made informed choices. It was thought that creativity came from confident, well-motivated pupils who have developed expertise in specific areas from working in a supportive environment. This, an art and design secondary teacher commented, came from the ability of the teacher to 'stand back', be a 'fly on the wall' and give regular feedback. Time for pupils to reflect and think about their ideas was considered important by the art and design teachers, but not highlighted by any of the design and technology teachers, though time to 'experiment' or 'spark ideas' was mentioned.

Constraints

These were common for both art and design and design and technology. They included concerns over lack of time, the impact of the National Curriculum and school inspections, large classes, addressing the needs of all of the pupils, costs for resources

and examination board requirements. One art and design teacher commented that his pupils needed both aesthetic and creative abilities and that 'realistic' designs also required good construction skills if they were to be really creative.

Findings from second investigation

The findings from the interviews with 'expert' teachers are discussed under the emerging themes of the nature of successful projects, group work and strategies to foster and teach for creativity. As with the first investigation the data was used to add to, and refine, the criteria within the three-feature model for creativity.

The nature of successful projects

All the 'expert' teachers agreed that creative problem solving was important with the need for pupils to work in a heuristic way, though Clive considered that some schools saw creative activities in very simplistic terms, for example 'Can you decorate our playground?' A number of successful design and make projects for pupils aged 11–14 years were described by Adam, Bev and Dawn where pupils observed, investigated, generated and developed ideas, made decisions, evaluated, synthesised, tested and evaluated the end product. Clive questioned the need to cover all these techniques in one project. He described a Year 10 project where pupils redesigned an asthma inhaler that focused on the development of an idea or a concept. The intended outcome was not to make 'a product' and the pupils were allowed to define their outcome including a web site, a foam model, a concept model or a mechanism. As a quality finished product was not the aim, the pupils were released from the constraints of having the materials and skills to make or 'construct' and they were able to concentrate on generating and developing ideas.

Group work

The issue of group work was discussed and Dawn thought that group work could be difficult, as pupils want personal ownership of their work. On the other hand, Adam talked of the advantages of de Bono and his six hats where pupils form groups and take on different roles either individually or as groups. He thought that 'ideas are free'. After pupils had 'brainstormed' or evaluated their work as a group they could work as individuals to design and make. Bev used group work for some parts of the project, for example 'brainstorming' ideas. She described the 'jigsaw approach' where a group worked together, went to different workshops and took back what they had learnt to discuss, teach and share with their peers. Clive and Dawn thought pupils would benefit from learning more about how design teams worked in industry. After-school classes to support pupils at the 'ideas' stage of their projects had been used by Adam, but this had been very time consuming. In hindsight, he thought that he would develop more group activities with pupils at this stage, for example 'a group 10 min evaluation when everyone put their model on the table'.

Strategies to foster and teach for creativity

Clive considered that the constraints of the English National Curriculum and other national strategies do not challenged teachers or make demands for creativity. Similarly, Dawn, as a young teacher with six years teaching experience in two schools discussed the impact of the National Curriculum on creativity in design and technology. She thought 'that pupils today are brought up (to think) that everything should be done right first time. There is no room for mistakes'. She commented that there was limited time for pupils aged 11–14 years to experiment and they were not used to it when they arrived in Year 10. She commented that showing the pupils exactly what they will do in Year 7 results in very similar outcomes and does not encourage creative thinking.

Adam considered that ownership was important and could be achieved through opportunities for the pupils to take and make decisions, for example, using their school building, flowers, a designer or a life style as a source of inspiration. 'I would never say you can only do appliqué, cannot change the colour or only have a square pocket' (Dawn). 'They have to take ownership; they have to want to do it. You hinder a child's own designing, you are numbing creativity. They get excited, you feed them little ideas and they go'. She saw the need for a real-life, stimulating brief 'You have been asked by a souvenir shop to produce something...' Bev's Year 7 pupils designed and made a new vegetarian product for Linda McCartney's vegetarian factory. In Year 8 they made a pasta product for a local Heinz Ready Foods factory, and in Year 9 'a new bread for your family' using flour from a local baker. She considered 'this type of brief captures the imagination of the pupils'.

Adam considered starting points for design and technology projects to be very important. He noted that 'lights could be an inspiration, a starting point for a radio, a key fob or anything. Look at the lines ... talk about symmetry, distance, balance, colour, grain, form, depth, 3D, things that are parallel ... do a rubbing put it in your folder'. He said 'designing earrings gives an immediate idea, but designing a body adornment for the ears ...takes on a different dimension. If you say ''design a storage box'' ... the pupils will make it square and a cube. If you tell pupils ''to draw a chair'' they will draw one with four legs, a seat and a back'. He quoted de Bono 'we do things in frames with labels'. He was clear that 'teachers need to think, how do we get outside the frame, break the mindset and think in a parallel way?' For example, 'you have got £20 to design something to sit on, use a piece of MDF to design something to sit on or design something to sit on that folds up'.

Clive thought the most exciting projects are 'when you don't know where it will end up', but they need 'a lot of stimulus materials'. Dawn showed pupils good examples of work then 'snatched then away so they don't copy it' but 'feed off it for their own creativity'. On the other hand, Adam considered that without stimulus pupil thinking is based on their view of the world. He called it 'Coca Cola', CNC or Chelsea Football design'. He noted that 'If you give a pupil a blank piece of paper without some stimulus and ask for five designs by the end of the lesson, their design will be based on 'their own very tight, closed perception of the world. The stimulus makes them think outside the frame'.

Other strategies to support creativity described by the 'expert' teachers included the use of 'flash cards' of tasting words during pupil feedback, or draw an outline or template of, for example a bag, and ask the pupils to go away and finish it (Dawn). Bev allocated time to incubate ideas during 'brain activities' on 'muffins' when pupils

thought creatively about marketing. The need for thinking time was mentioned by Dawn who saw homework as an opportunity for that 'extra input'. She encouraged pupils to experiment and try out ideas and techniques when they made appliqué samples. She gave them scraps of fabric and time in a lesson to use the sewing machine to try different stitches and approaches.

When asked what the 'expert' teachers felt most helped pupils to be creative, they responded with 'learning that if it does not work it does not matter' (Dawn). Second, 'being confident and relaxing, in a positive environment where success is valued so it does not matter if they make a mistake and we are not challenging their weaknesses'. 'We get them into what I call 'free-flow' mode; they have got to flow' (Bev). She suggested putting non-creative pupils with particularly creative pupils. Third, Adam thought 'stimuli, talking, dialogue and modelling were the key'. 'Seeing pupils jumping up and down in the corridor and whistling happily was such a pleasure to see. ... when they come up with something they have laboured over, absolutely fantastic'.

Findings from third investigation

The data from the classroom observations of the two units of work (a) 'The Grabber' and (b) 'Health eating' was mapped and analysed against specific criteria in each of the three features of the model for creativity. The findings are discussed in the context of the emerging themes of classroom activities, the strategies used in teaching these activities and the reflections of the teachers.

Domain relevant features: set of practices associated with an area of knowledge

Concept/idea: In unit (a) the brief was set by the teacher in a realistic setting through modelling a pneumatically driven processing machine in a 'Mars bar' factory. It focused on functionality with very limited opportunity for pupil originality. In unit (b) the context encouraged a variety of types of lessons and encouraged originality e.g. choice of ingredients and the product for the lunch box.

Aesthetic: In unit (a) the only reference to aesthetics was the teacher directive to develop a simple design and use minimal materials. In unit (b) the pupils were required to consider appearance (chocolate, nuts, and decoration), flavour (grill cheese), smell, texture (lettuce and cucumber), colour (green vegetables) and use their personal, and emotional preferences.

Technical: The teacher in unit (a) emphasised knowledge and understanding of mechanism e.g. types of levers, and pneumatics (air) through the use of syringes. The pupils were required to apply this when sketching in their course booklets and modelling ideas to develop and make their final 'grabber' design. Unit (b) also emphasised the technical knowledge and understanding of food as a material for pupils to make design decisions. For example, ingredients to thicken, strengthen and stabilise structures (eggs, flour) and baking powder to make mixtures rise. Pupils used this effectively to make a wide range of design choices in their food products.

Constructional: In unit (a) the teacher taught knowledge of mechanisms and demonstrated the product analysis activity. Pupils used tools and equipment when trying out ideas and making their final design prototype. In unit (b) the teacher did 'spot' demonstrations for skills as and when they were necessary. The pupils carried

out product analysis activities e.g. on varieties of crisps, packaging materials and made a range of products. They used a variety of tools and equipment and processes to make a pasta sauce based product, a chilled dessert and product of their own specification for a healthy lunch box.

Process relevant features: influencing, controlling the direction/progress of the process

Creative problem solving: The teacher set a semi-open brief in unit (a). The pupils watched a demonstration and were asked to find examples of pneumatics and hydraulics for homework. They were encouraged to try out ideas, use different techniques, test and modify to solve the set problem. In unit (b) the teacher set the scene, provided a framework and allowed pupils to work through a series of activities each week. Pupils observed, investigated, synthesised, developed ideas, evaluated and modified ideas e.g. classification of foods according to functionality, use, taste and made decisions on the ingredients for each lesson. They developed recipes, tested criteria such as consistency and used a variety of processes e.g. cakes, biscuits, salads.

Organisation: In unit (a) the teacher planned the lesson's teaching strategies to include whole class teaching and demonstration, small group and individual work and some time for 'incubation' or dwell time for homework. Analysis and self-organisation by pupils was encouraged. In unit (b) the teacher focused on group work, set time targets, brainstorming activities and wrote flow charts on the board. Pupils were self-organising for their ingredients and equipment and they were required to synthesise, incubate and develop their ideas between lessons.

Personal: In unit (a) the teacher set the brief in an interesting context, set time targets and used periods of silence to encourage pupil concentration. Pupils worked individually or in groups and the teacher supported when necessary. In unit (b) the teacher set up activities and encouraged pupils to work co-operatively. The pupils were pro-active, independent and one was particularly noted for a willingness to take risks e.g. in their choice of product to develop.

Social and environmental features: the social, cultural influences macro/micro-environment

Background: Unit (a) was not successful at building on the pupils' previous school experience in Year 7 and there were lost opportunities to identify progression in learning. In unit (b) the teachers related lessons well to pupils' previous experiences at home e.g. family and peers and a Year 7 unit of work.

Use of external/transferable knowledge, understanding and skills: There was evidence in the lessons of unit (a) of the key skills of collaboration, communication, numeracy (measuring materials) and literacy (reading instructions, writing and recording in booklets. Pupils talked, wrote about, sketched, measured and recorded their designs. In unit (b) there was similar evidence of literacy, numeracy and communication but the use of pupil collaboration and group work were more developed. Problem solving of a brief was present in both units, but there was no evidence of researching for homework or the use of ICT in either.

Handling outside/conflicting constraints: The teacher and pupils in both unit (a) and (b) were aware of an observer in the lesson. Pupil groups were organised by the

teacher and there were planning constraints in both units of having to conform to school assessment schemes. In both units there was a need to work as a team with peers and sharing resources. Pupils in unit (b) were expected to provide ingredients for the lesson and were made aware of other peoples' likes and dislikes.

Appreciation of alternative ideas and experiences: The brief in unit (a) related to the world outside school and pupils were required to listen to and work with peers. No links were made with other subjects. In unit (b) pupils made stronger links with other subjects e.g. science (starches, melting fat, thickening).

Motivational: In unit (a) the teacher provided extrinsic motivation through an industry related brief, praise, clear lesson targets, completion of a course booklet, assessment through a class competition (reward of Mars bar) and the school assessment scheme. Intrinsic pupil motivation was not evident. In unit (b) there was a combination of extrinsic motivation from the teacher and the security of using basic recipes. Intrinsic motivation opportunities were available for pupils through the choice of ingredients and the development of their own specification for the lunch box. Books, videos and samples were used to stimulate ideas.

Environmental: In unit (a) there was a supportive, rewarding environment but limited equipment and the need to dismantle their models after each session restricted the pupils. There were good peer relationships. Risk taking was restricted to some extent by a wish to 'win' the competition and the school assessment scheme. In unit (b) there was a calm, working environment where pupils could listen to each other and think. There was a good range of resources within a secure environment. Pupils worked in groups and individually and were made aware of peers' ideas and values.

Discussion under emerging themes

Classroom activities

In lesson 1 for unit (a) 'The Grabber', the teacher introduced the project and brief and gave the pupils their course booklet. The pupils were asked to complete a worksheet of nine questions and analyse their proposed grabber, for example 'How will the syringes be held on the grabber?' and 'What size of materials are available?' The class was shown the equipment they could use through a teacher-led product analysis activity introducing new technical language. Written homework was set to find out as many different uses of pneumatics and hydraulics as possible and complete a worksheet. It was a well managed, teacher led lesson with no opportunity for 'hands on experience' for the pupils. The pupils were passive, receptive and worked individually on paper based activities from their course booklets. Generally lessons were teacher led by whole class teaching, followed by individual work and pupils were expected to find out basic knowledge for themselves for homework. To motivate them they would get a merit point and a Mars Bar if they were successful. No links were made to work in Year 7 on electronics control, where pupils had used the computer control software 'Crocodile Clips' to simulate a series of electrical circuits.

Lesson 1 of unit (b) 'Healthy Eating' as in unit (a), focused on the knowledge needed to be taught, for example the functions of ingredients. A colourful 'Food Function' poster was used to stimulate a discussion with the pupils. The class was

divided into pairs to discuss and then individually complete a worksheet providing examples of foods to fit functions such as 'thickening' and 'aerating (holding air)' to use in a 'taste testing' activity. Groups of pupils did a 'taste testing' activity using a range of crisps and completed 'taste testing' charts individually. The class was given the basic recipe for macaroni cheese for the next lesson, followed by a teacher led discussion on the modifications they could choose. Much of the knowledge covered in the lesson was new, but links were made to Year 7 and progression was evident.

The two units varied in the way they were constructed. In unit (a) lesson 2, pupils completed the booklet page of four initial ideas for their grabber and produced a working card model. In lesson 3 they were required to produce a sketch of their final design and produce a model, which had to be taken apart at the end of the lesson due to a shortage of resources and rebuilt and refined in the following lessons. In lesson 6 of unit (a) the pupils produced their final grabber design, individually tested it, and again had to dissemble it. It was not until lesson 7 that they tested a final model as part of a class competition. In unit (b) following the focused practical tasks to develop knowledge and skills, the pupils developed a specification for a lunch box and produced one of the three products over a period of four sessions. The first activity when developing the specification for their lunch box was a 'task analysis' and they had to develop three products one sweet, one savoury and a drink from a brainstorming of ideas. The pupils tended to gauge for themselves what they could make, though some needed more teacher guidance. They planned the lesson before the practical session and talked through with the teacher what they needed to bring. If their ideas were not very healthy they had to rethink how they could improve this. The teacher commented 'I was surprised by the list of ideas I had from them, they really enjoyed saying 'what about this and what about that?'

In unit (a) the outcomes were a limited range of types of poor quality grabbers, which had to be dismantled each lesson due to a lack of resources. Unit (b) contained a wider range of focused practical tasks, including the chilled dessert and pasta based products in the early sessions. As a result pupils had a broader base of knowledge and skills to draw upon when making their design decisions. There was a much wider range of good quality products produced by the pupils when they developed their own specification for the packed lunch using a range of resources.

Teaching strategies

In both units there was a teacher led discussion at the end of the lesson to evaluate progress and highlight key issues relevant to future lessons. In unit (a) each lesson was structured so that a group of pupils shared a bench with four to five pupils but worked individually. They were encouraged to ask the teacher rather than co-operate as a group or move around the workshop talking to each other. In unit (b) the approaches taken were more varied, the class was taught together by the teacher, pupils worked on their own but were more often in co-operative groups. There were limited opportunities planned for the pupils in unit (a) to share and discuss their work, but in unit (b) they were encouraged to develop this aspect further with their peers in class discussions. In both classes the teachers moved around the room supporting and giving guidance to pupils.

Course booklets were used in both units of work, indicating this was departmental and school practice. Pupils were expected to complete them during lesson, for example in lesson 2 of unit (a), pupils were required to sketch four ideas and in

lesson 3 produce a cutting list for their grabber. For homework in lesson 1 of unit (a), pupils researched the uses of pneumatics and hydraulics and evaluated their final design in lesson 6. In lesson 1 of unit (b) pupils looked at recipes and identified the functions of the each ingredient and in lesson 3 analysed the properties of packaging materials. In lesson 5 of unit (b), pupils analysed the label of their ingredients used to produce their chilled dessert and completed a sensory analysis chart using the hedonic scale. The majority of tasks were individual though some, for example the 'taste tasting' activity for flavours of different types of crisps of lesson 1 in unit (b), was a group activity.

In unit (a) the teacher expected pupils to explore the problem, try out types of levers and work out what problems might arise and how to solve them. She commented 'Rather than saying that's your specification it was a way of them thinking how they could solve problems and what problems they had to solve'. It was intended that the new technical knowledge was covered at the beginning of the unit through practical tasks, but this was not done in a structured manner. The unit linked to a later unit where the pupils revisited levers and linkages, but did not build on earlier work. Teaching about the concepts of pneumatics and mechanisms was limited resulting in a lack of basic understanding.

In comparison in unit (b), the teacher covered knowledge and skills through a series of well-focused short tasks in the early lessons. Lesson 1 focused on teaching knowledge through short activities about the functions of food that was applied in later lessons. In lesson 2 pupils were given a basic pasta recipe and expected to adapt or modify it in some way, for example use Red Leicester cheese for colour and flavour, have a different portion size, use a different type of pasta, bake or grill or garnish. The teacher commented 'They were making design decisions without even realising it... I was quite surprised ... how differently they were using the same recipe'. The structuring by the teacher of the activities ensured that all the pupils learnt the underlying concepts and knowledge to enable them to make design decisions. Lesson 3 had a focus of 'packaging'. The pupils watched a video on packaging of foods highlighting issues such as the environment, pollution, transport, had a class brainstorming on types of packaging and a group activity analysing materials used in packaging. In lesson 4 when the pupils made a chilled dessert they could vary the colour and flavour of the filling, for example chocolate, raspberry or lemon. The type of biscuits for the base, for example digestive or ginger biscuits and for decoration the use of chocolate buttons, flaked or grated chocolate or hundred and thousands.

When the pupils developed a specification for a lunch box the teacher said 'I gauged their practical skills through the short tasks and encouraged some pupils to be more creative. ... One pupil demonstrated some really good skills ... so he did ginger biscuits, which was quite adventurous and nothing went wrong with them. ... I felt even though they choose different colours and decorations when they adapted the recipe, they focused more on the making, reducing the time for making it look good'.

Teacher reflections

For unit (a) the teacher's declared main aim had been to get pupils to overcome a problem on their own. She felt they responded well to the context of a chocolate factory. This approach was a new concept for the pupils in this area of design and

technology as her colleagues did not expect them to solve the problem on their own. They had needed more guidance than she had expected, whereas she had hoped to 'leave a lot open for them to work things out for themselves'. The teacher acknowledged that it was not clear what the pupils had learnt in the unit and whether they understood pneumatics. Variation in the design of the 'grabbers' was not a priority; functionality was the key issue.

The teacher felt that some of the pupils had handled making decisions very well, 'They really thrived on it, especially when there was no written work. Others liked to sit and watch the rest of the class'. She acknowledged that giving a class a task and saying 'This is what you have to do and you are on your own' did not have the potential for success for all pupils. The teacher equated 'good decision-makers' with more academically able pupils and cited an example from a class of such pupils where she had found a better response to the 'open-ended' approach. Yet this view did not match the data in this study as the less academically able pupil D, who normally was difficult to settle, had worked well in the open-ended approach and was successful and original in his response. In hindsight, she thought 'It was really a case of guiding them constructively'. She commented that in the future 'I would produce sheets of activities on levers which they had to complete, both drawing and writing with reflection of what they had found out'. They would be expected to draw an idea and share it with the rest of the class. 'I would give them more construction exercises at the beginning such as working levers and ways of using syringes'. The teacher did note that the biggest problem was the lack of resources. 'It was a new unit and we did not want to spend too much money if it was not going to be done again. However, we now have decided to repeat it and will buy extra resources' so the models will not be taken apart at the end of each lesson'.

When asked to reflect on strategies that could be used to foster creativity in the design and technology classroom, teacher (b) suggested providing the basic knowledge and skills so that pupils could succeed, recapping and discussing ideas and seating arrangements in the classroom as without these key criteria pupils would become disheartened. 'I matched pupils like B and D to help them, spur each other'. 'Time is an issue as it takes time to weigh out ingredients. Doing this at home leaves more time for being creative, but it must be accurate'. She concluded that in the future 'I would try and give them more ideas, not answers' by asking them to think about how they can adapt their recipes using for example the use of sun-dried tomatoes. She quoted another teacher in the department, who with a weak class, provided stimulus by bringing in a tortilla wrap for pupils to look at.

Conclusions

During the five year time span of this research in England there have been government initiatives related to creativity such as the Key Stage 3 (11–14 years) National Strategy, Foundation Subjects: Design and Technology (DfES, 2004). In 2000 there was recognition by the Design and Technology Strategy Group, supported by the DfES (Barlex, 2003b), that there was a need to examine the approach to pupil assessment in design and technology as it 'was widely regarded as having become formulaic, routinised and predictable' (Kimbell, 2004, p. 100). It has become increasingly evident that a number of pressures had combined to reduce innovative performance in school examinations for learners, aged sixteen and eighteen years,

'Playing safe with highly teacher managed projects has been seen to be the formula for schools guaranteeing A-C pass rate'. Recently attempts have been made to explore innovative ways of assessing creativity in design and technology (Kimbell, 2006). Essentially, his projects explore the use of digital tools and virtual portfolios and a shift of balance in favour of learners who can demonstrate innovative, risk-taking performance. However, in the context of this paper it is important to note that the research was concerned with the creativity of the ordinary rather than the extraordinary, or gifted, pupil, (Craft, Jeffrey, & Leibling, 2001) and did not attempt to use quantitative approaches to measure or assess the complex concept of pupils' creativity.

When teaching for creativity as described in the Robinson Report (1999) it is suggested that teachers fall into one of three categories. First, there is a minority of teachers who have an interest and intuitive ability to foster their pupils' creativity. In the context of this research they are referred to as 'expert' teachers. At the other end of the spectrum, there is a minority of uncreative teachers who value knowledge as presented in national tests and examinations and favour 'hegemonic' pedagogy that is teacher led and authoritarian (Murphy, 2003). These are the types of teacher, mentioned by the systems and control 'expert' teacher who influence and prevent changes of pedagogy in a school. They prefer traditional teaching methods and associate with the formal instruction of specific skills and content (Robinson, 1999). Their implicit theories of effective learning and teaching are based on notions of transmission of knowledge and control of learning (Dow, 2003, 2004) and if left unchallenged they will find it difficult to create structures and environments that encourage creativity and will resist any attempts to modify their approaches.

Summary of findings from sub-research question 1

> What can design and technology teachers learn about teaching for creativity from the practices of art and design and design and technology teachers?

Overall, there were common factors for art and design and design and technology that indicated the importance of a supportive school ethos for creativity. These included teachers with an ability to integrate teaching strategies into their lesson's aims and objectives that fostered their pupils' creativity. Other important factors included head teachers that support and sustain creativity within their school culture, a local environment with resources that help stimulate creativity and well-qualified, committed teachers.

The development of technical creativity was generally the main focus for design and technology teachers, especially in the lower secondary school. This was considered important by art and design teachers but they highlighted the importance of aesthetic and constructional creativity and the need for pupil choice and decision-making. The art and design teachers placed more importance on allowing pupils to make their own design decisions, having time for reflection with time to think through their ideas and developing aesthetic criteria. In contrast a key factor for secondary design and technology teaching was the restrictive type of design brief frequently set that 'closed down' creative thinking from the beginning of the 'project'. Pupils are going to design and make a '.....'. Particularly in the lower secondary, the context and the use of interesting and visual stimuli was not of high importance and the teachers did not value motivating pupils by exploring, observing

and considering different, but relevant, outcomes. In secondary design and technology the design strategies used were generally limited and did not include group work or developing knowledge and skills alongside opportunities for making design decisions to produce originality.

Discussion

Schools visited during the first investigation valued and invested in creativity but it is interesting to note that within these institutions that were supportive of creativity there were significant differences between art and design and design and technology. In both secondary and primary art and design lessons teachers organised the work as theme based projects and pupils were expected to explore the themes, often collaboratively, investigate materials and techniques leading to outcomes that were individual to the pupils concerned and driven by the pupil's own ideas. In primary design and technology lessons there was some evidence of this approach being used although the nature of the product designed and made by pupils was much more prescribed with each pupil usually designing and making the same type of product. In secondary design and technology lessons there was no evidence of the use of this approach and pupils worked almost exclusively as individuals. The type of product was prescribed and there was little variation in the products designed and made by different pupils.

In terms of the three essential features in the model identified from the literature on creativity it appears that art and design teachers give similar weight to the three features (domain relevant, process relevant and social, environmental features) whereas design and technology teachers, particularly at secondary level, seem to consider mainly domain relevant features with an emphasis on the technical and the constructional but even here the opportunity for pupils to be creative was severely limited. The lack of creativity in response to domain relevant features is perhaps inevitable when the other features of the model are absent. The priority given by art and design teachers to giving pupils the opportunity to think and develop their own ideas was absent from the teaching of secondary design and technology. This indicates that the teaching strategies used in secondary design and technology, unlike those found in art and design, had more in common with the 'hegemonic' or traditional style as described by Murphy (2003). This was not the situation in the primary schools where the pedagogical tradition of group activities (John-Steiner, 2000) and the use of a range of teaching strategies were common practice for both art and design and design and technology teachers.

Summary of findings from sub- research question 2

Interviews with 'expert' teachers:

> What strategies can be used by design and technology teachers when teaching for creativity in the classroom?

Key findings cited by the expert teachers included a better balance between aesthetic, technical and constructional creative criteria with more emphasis on aesthetic than is the present situation. Similarly, they valued the use of creative, heuristic problem solving rather than the frequently found focus on teaching 'skills'. They highlighted the need in curriculum planning for a 'creativity' learning objective;

otherwise it will become lost and ephemeral with a low profile. However, there was recognition of the restrictions of time; money and resources but suggestions were made to overcome this, for example a 'multi-tasking' curriculum across specialist areas. Progression from the 7–11 to the 11–14-age range was seen as essential with an adoption in the lower secondary of many of the teaching for creativity approaches used in primary schools. The 'expert' teachers favoured the use of formative assessment, or ongoing, continuous and supportive assessment, as it feeds and develops pupils' creative thinking and designing.

They suggested that a framework of strategies for pupil motivation and stimulation would be helpful, though acknowledging that some teachers would require guidance and support in their use. Overall, they considered that pupils should be taught to communicate and develop their ideas through a range of strategies in the lower secondary years as a foundation for design and technology courses in the older age range. The use of group and team work with peers was seen as especially effective. The 'expert' teachers saw a need for interesting, motivating and relevant projects, with exciting starting points and stimulus materials to develop and open the pupil's minds. They questioned the role of the traditional 'design folder' and made suggestions for alternative approaches. No 'expert' teacher favoured class course or unit booklets with sets of written tasks. Finally, a relaxed, calm, positive, secure classroom environment was seen as essential to ensure that pupils to have the confidence to take risks and try out ideas.

Discussion

The interviews indicate that the 'expert' teachers knew of, and had used, a wide range of strategies that can be successful when teaching for creativity in the design and technology classroom, though some may be more appropriate for particular specialist areas depending on the age of the pupils, the project and the individual style of the teacher. The strength of the data collected was on the range of strategies or 'tasks' that they had used successfully with pupils. However, during the interviews the 'expert' teachers discourse about creativity was limited as they often referred to a list of 'tasks' and did not put them into the context of the social or environmental issues of the classroom as outlined in the model. It was the researchers who made this connection when the data was mapped against the three-feature model for creativity. Their practices did, for example, include ways of motivating pupil that enhance the social and environmental aspects of the classroom and so affect the creative processes of the pupils. However, the importance of such activities in a process or systems approach where creativity occurs at the interaction or convergence of a range of features, including the social and cultural environment of the classroom (Amabile, 1983, 1989, 1996; Csikszentmihalyi, 1999), was not highlighted.

The practice of the 'expert' teachers was acknowledged to be exemplary in teaching for creativity so it is interesting to consider their comments on their practice in terms of the three essential features in the model identified from the literature on creativity. They all valued collaborative learning yet indicated that more could be made of this and that on occasions there were difficulties. They were clearly supportive of environments where fear of failure was not an issue, ideas were shared, and it was possible for pupils to 'get lost' in their designing. This indicates that the social environmental features are a significant part of their approach to teaching for creativity.

All four teachers saw creative problem solving as an integral part of designing and resisted the use of algorithmic approaches, hence none of them used a structured booklet approach to support pupil designing. They saw designing as an heuristic activity in which a pupil makes 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. The repetition of 'what if' moves increases the pupil's understanding of the issues, thereby informing, guiding and stimulating further designing (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). This indicates that they all had a clear grasp of process relevant generic features required to support designing and making in design and technology and used this in their approach to teaching for creativity.

Intriguingly they talked very little about domain relevant features. This is perhaps not surprising as the exact nature of the knowledge required to solve a design task is not known in detail at the beginning of a design task, the designer gathering the required knowledge together on an as needed basis. It appears that these teachers expect their pupils to deal with uncertainty and find out knowledge where necessary although in all the project examples that they quoted there would undoubtedly have to have been some domain relevant feature teaching. This was demonstrated by Adam's starting points that prevent stereotypical responses, Dawn's snatching away of good examples to avoid copying, Clive's view that uncertainty is the basis for the most exciting projects, and Bev's 'going with the flow', and find out when necessary.

As with the secondary art and design teachers these teachers, experts in teaching for creativity, did not adopt a hegemonic style (Murphy, 2003).

Summary of findings from sub- research question 3

> What is the present situation in fostering creativity in design and technology classroom for pupils aged 11–14 years?

The findings from the school based study indicated that the quantity and quality of creative problem solving is directly influenced by the brief set by the teacher and the structuring of lessons. There was a lack of balance between developing knowledge, understanding and skills and providing opportunities for pupils to work in a heuristic way and make their own decisions. A brief, such as 'the grabber', includes problem solving but it was not presented as a creative problem solving activity as the decision making lay mainly in the hands of the teacher rather than the pupils. Unit (a) had a realistic setting, making links with the outside world, but did not provide the potential for pupils to be creative. The focus on functionality and one type of mechanical outcome over a period of weeks did not allow pupils to show originality or any form of novelty. The early lessons were closely structured with limited opportunities for design decisions. Some creativity was possible when the pupils developed their own 'grabber', but these were limited by resources and, to some, extent time. Aesthetic factors were limited in unit (a) but well covered in unit (b). It is likely that evidence of certain criteria will vary across focus areas of design and technology and age phases. However, the findings indicate that there were lost opportunities for interesting and motivating activities, especially in unit (a) and a lack of opportunities for research, though they were stronger in unit (b). Technical and constructional criteria were covered well in both units.

There was limited reference in both units to pupils' previous personal or educational experiences and a disappointing lack of links with other subjects in the curriculum. In both units there was evidence of the use of transferable skills, though the use of information communication technology (ICT) was missing from both units. Assessment, and the need for high grades, appeared to hinder pupil willingness to try out new ideas. There was little evidence of intrinsic motivation, as it was the teacher and school that provided a range of extrinsic, motivational practices. There was only a limited use of stimuli to motivate and interest pupils as starting points, especially in unit (a). Classroom management was strong in both units and pupils were encouraged, especially in unit (b), to develop the skills of self-organisation. The range of teaching strategies and activities used in unit (a) were limited, though the situation was better in unit (b). Here a range of different tasks and activities were used to build knowledge and understanding using group work and other more 'open-ended' approaches and opportunities for pupils to make design decisions to develop, or create, their own product. Incubation, 'dwell time' to think or reflect was evident in unit (a) but not well developed in either unit, with more opportunities noted in unit (b). The pedagogy used in unit (a) was mainly hegemonic and traditional.

Though the teachers in both units were keen to develop new pedagogical approaches, the traditional style used by fellow school colleagues of the teacher in unit (a) had a marked impact on her ability to implement new ideas and styles. Despite overall support from the head of faculty the approaches in unit (a) were new to the pupils in this area of design and technology and they took time to adapt to the teacher's expectations. This, together with a lack of appreciation, support and provision of resources by senior colleagues made it difficult for her to create an environment that would foster creativity. This has implications for supporting newly qualified teachers aiming to foster their pupils' creativity. Individual teachers, particularly young teachers, within an unsupportive department are likely to encounter difficulties.

Overall, in both units the teacher was the key factor in fostering creativity by influencing pupils, for example, to be tolerant, take risks and be pro-active. A key factor was the ability of the teacher to provide a secure, rewarding, supportive, well-resourced and safe classroom environment where pupils were encouraged to take risks and work co-operatively. The role of the teacher was seen in the case study as the crucial factor for successfully fostering creativity rather than any differences there may be across the specialist areas of the design and technology curriculum.

Discussion

The importance of classroom and curriculum organisation and management by the teacher, as noted in the case study, highlighted the need for a calm, supportive environment conducive to confidence and risk taking. This has resonance with Amabile (1983, 1996), who argues that these criteria can maintain or kill creativity and motivation. The results of the school based case study, though revealing, were disappointing in that they indicated that fostering pupils' creativity and teaching for creativity were not key issues for either of the teachers of pupils aged 11–14 years. Though, on reflection during the interviews they were able to discuss how this could be achieved.

The approaches taken by the two design and technology teachers who were observed in some detail in the school based study reflects the overall approach taken

by secondary design and technology teachers in the first investigation. There were some common features: the use of course booklets to underpin progress throughout the sequence of lessons, the emphasis on individual working and the production of a final product decided to a large extent by the teacher. However there are interesting differences. The food technology teacher adopted an approach in which learning through a sequence of small tasks prepared pupils to make the design decisions needed to be successful in the designing and making assignment. Also the nature of the food product was less prescribed than the systems and control product. The food technology teacher gave her class the chance to brainstorm ideas for three products (one sweet, one savoury and one drink) and '...was surprised by the list of ideas I had from them.' The range of food products designed and made was much wider than that achieved in the systems and control lessons. To some extent this was inevitable, as the teacher had prescribed the product as a pneumatically controlled 'grabber' consisting of linked levers. But the opportunity for the pupils to generate novel solutions was limited by the lack of teaching about both pneumatics and linked levers. Without this understanding the pupils were restricted to a basic 'try it and see' approach to developing their solution. The teacher of this unit realised that she was asking the pupils to adopt a problem solving approach but admitted that the pupils had needed more guidance than she had expected, although with hindsight, this was understandable, as most of the teaching in this area of design and technology did not require pupils to be problem solvers. Interestingly the pupils enjoyed being in this new situation, one in which they had to make decisions for themselves, even though the quality of these decisions did not lead to particularly varied or creative products.

In terms of the three essential features in the model identified from the literature on creativity it appears that the food technology teacher gave more weight to the process relevant and social, environmental features than her systems and control colleague. The food technology teacher explored the four components of the domain features much more extensively. She enabled pupils to develop their own concepts albeit to a limited extent. The pupils had some control over the final appearance of their product (aesthetic creativity) and how the product worked nutritionally (technical creativity). The use of recipes as starting points clearly limited constructional creativity but the teacher was sensitive to pupil's constructional abilities in negotiating their response to the task. This is clearly some way from a hegemonic approach.

The systems and control teacher focused almost exclusively on technical problem solving, thus excluding the possibility of utilising process relevant and social, environmental features although she had situated the task in a context that appealed to the pupils—a sweet factory. Within the domain features her approach concentrated almost exclusively on technical creativity, although with the limited previous experience of problem solving success was inevitably limited. Problem solving approaches to such technical problems are well known and have been shown to be effective with secondary school pupils (Barak, 2005) and in different circumstances with an induction to such techniques the response of the pupils may have been much more creative.

Overall, the differences between the pedagogy adopted by the two young teachers noted should be considered in the context of the school. The systems and control teacher was enthusiastic and keen to implement new ideas, but the senior staff in her area of the design and technology department made no effort to support her efforts. For example, they showed no interest in the research project despite support from

the head of faculty, they did not provide any extra resources resulting in the pupils having to dismantle their models after each lesson. She taught in a dark, traditional workshop with workbenches arranged around the room and a white board and there was no open area for pupils to develop and present their ideas. Attempts to introduce new pedagogical approaches were difficult as the pupils were used to an emphasis on 'making' in line with the established traditional workshop practices of her fellow colleagues.

In contrast the food technology was taught in a light, newly furnished food technology room divided up into working areas including worktops, a range of equipment and a writing area. The food technology teacher was also keen and enthusiastic but she had the support of her colleagues in food technology and was encouraged to implement new ideas. It was noticeable in the food sessions that the pupils were more used to working in groups, choosing and using a range of resources, discussing issues and developing and trying out their own ideas.

Although the creativity exhibited by pupils in these design and technology lessons was limited, such creativity that was present was the direct result of the teacher and the teaching situation they orchestrated. The teacher was the key factor in fostering creativity by influencing pupils, for example, to be tolerant, take risks and be proactive. Similarly, in both units the emphasis was on the teacher to provide a secure, rewarding, supportive, well-resourced and safe classroom environment where pupils were encouraged to take risks and work co-operatively. The role of the teacher was seen in this small case study as the crucial factor for successfully fostering creativity.

Implications for classroom practice

Although the study is based on small sample it still has salient points and a wider, in-depth research project would add more credence and understanding to the results. However, the analysis of the emerging themes based on data mapped against the theoretical three-feature model for creativity provides some evidence of the current situation in the classroom for pupils aged 11–14 years and adds to the current debate regarding the development of creativity in design and technology in England. The model has the potential to be used in an international context as the issues discussed will have similarities, though specific criteria within the model would require attention before its use.

The strength of the three-feature model for creativity is that it can be used as a mapping tool for collecting data from classroom observations and so analyse classroom practice for evidence of good practice and areas that need to be addressed. It has an additional potential as a tool to analyse teaching resources for their usefulness in fostering creativity in the classroom. As a model it focuses on the three features that need to converge if pupils are to be truly creative in the classroom (Csikszentmihalyi, 1994, 1999; Feldman et al., 1994). These are the subject domain's knowledge, understanding and skills, the creative processes and a supportive social and cultural environment. However, the model is not perfect in that some criteria may overlap across two features. For example, the personal criteria in the process relevant features highlight a pupils' ability to be imaginative, work in a team and take risks. These have links with motivation in the social and environmental features where intrinsic motivation, curiosity and persistence of pupils is fostered by relevant, real-world and open-ended approaches.

As an evolving model the specific criteria highlighted within each feature can be further developed. The model has the potential, not used in this research, to investigate the balance and dynamic of creativity across the three dimensions and assess the varying impact of each of the three features on pupils' creativity. An example of the application of the model is discussed by Steeg and Martin (2005) where it was used to explore the opportunities for pupils to engage creatively in an electronics unit of work. The importance of design and technology teachers evaluating and developing their pedagogical practice is a major issue and the framework in the model provides a tool that could be used to address this through local, national and international research projects.

The mapping of data from the three features of domain, process-relevant and social/cultural/environmental indicated that the social, cultural and environment criteria of the model should have a higher priority for teachers than is the situation at present. This would focus their thinking, prevent the issue of creativity remaining ephemeral and highlight the importance of including a learning objective for lessons related to creativity. It would enable them to foster creativity in the design and technology classroom and have a direct impact on pupil motivation and the quality of the learning experience. It is the role of the teacher that is crucial in developing pupils' latent creativity and is instrumental in creating the social, cultural environment of a classroom that fosters pupils' creativity.

Current practice in design and technology for pupils aged 11–14 years in England as described in the literature (Barlex, 2003a; Kimbell, 2000; Kimbell et al., 1995; Murphy, 2003) and exemplified in the three investigation reported here does not meet the criteria for creativity as described in the Robinson Report (1999). It is disappointing that the weaknesses noted in the school based case study reflect the serious concerns expressed by Parker (2003) regarding the lack of 'designing' in the teaching of design and technology.

In order to enhance teaching for creativity in design and technology for pupils aged 11–14 years and beyond, secondary design and technology teachers can learn from art and design teachers in terms of an overall approach which would encourage more conceptual design i.e. ideas for different sorts of product and greater aesthetic awareness in developing the appearance of products. It will be important not to compromise the functionality of products by over emphasis on the aesthetic but prescribed functionality can be avoided through appropriate pedagogy in which small tasks are used to generate knowledge, understanding and skills required for success in a designing and making assignment.

Embedding creative problem solving in a design-based approach to generating, developing, making and evaluating as exemplified by 'expert' school practitioners in teaching for creativity, will require many teachers to reflect on and adapt quite considerably their current practice to ensure that it embodies a suitable treatment of the three essential features in the model for creativity. This is not a trivial task and teachers will need to be supported through sustained and substantial professional development to achieve this goal. The provision of this professional development would be a significant undertaking in England, and an international context. To be successful it will require collaboration between professional associations, institutes of higher education and agencies involved in teacher education.

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