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Enhancing Student Teachers’ Design and Technology Subject Knowledge Using a Situated Cognition Perspective
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Abstract
The research described in this paper focuses on the learning of primary PGCE students and how this affects their teaching of design and technology in schools. The paper examines how students may be initiated into the professional traditions of designing and making which exist outside schools and colleges. It explores design and technology specialism, students’ beginning to understand how problem solving is dealt with by professional designers and makers in the workplace. Qualitative methodology is used to analyse students’ discussion with professionals and to chart the subsequent shifts in their understanding. Evidence shows how students may begin to view learning as a process of enculturation through shared activities into a community of practice, which can result in them presenting children in school with authentic problems to solve drawing on their ‘knowledge in action’.

Keywords
primary, PGCE, subject knowledge, situated cognition, problem solving, professionals

Introduction
Teacher trainers in design and technology with their intensive teaching programmes and extended relationship with trainee teachers, schools, and often professional designers and makers, are uniquely positioned to generate rich and contextualised practitioner knowledge. This knowledge gained through research can capture the real experience of their student’s struggle to understand and teach design and technology in schools. The research described here set out to explore student teachers’ understanding of how the problem solving strategies of professional makers are devised and used in the workplace. It also aimed to trace how this understanding may affect students’ knowledge of design and technology as a curriculum area, their attitude to the subject, and their teaching in the classroom. The findings were used by tutors as part of the evaluation of the 1999, ITE Postgraduate Specialism Course at London University, Institute of Education, and by students in their written assignments.

As part of the specialism course in design and technology, student teachers were given the opportunity to visit a range of professional designers and makers to discuss their work. They met with a jewellery designer, automata maker, workers in a ceramics studio, furniture designers, and makers of large scale architectural projects. It was hoped that students would gain an understanding of the commercial and professional practice of designers and makers, through discussing design and make processes and approaches. Students viewed plans, working sketches, and computer aided design, and handled industrial models, test pieces, and finished products. They were encouraged to see similarities and differences between problem solving in design and technology within the primary curriculum and world of work, and to make links between the quality of their own learning, their developing knowledge and understanding of design and technology, and their ability to teach the subject in schools.

Student subject knowledge
Research questions revolved around whether these experiences would enhance or extend aspects of student subject knowledge in design and technology. Schulman (1986) identified seven subject knowledge bases as necessary for effective teaching. Garvey (1996) noted that Ellis (1995) had developed this analysis further. Relating these general curriculum aspects to teachers’ subject knowledge in design and technology provides the following list:

- distinctive aspects of the subject, beliefs and values associated with the subject and its role in modern society
- knowledge about the management of learning, organisation of the learning environment and working with other teachers
- substantive content knowledge or the concepts of the subject, such as products and applications, quality and technical vocabulary, mechanisms and structures, and health and safety
- pedagogical content knowledge or aspects of the subject relating directly to learners, for instance the way children learn, and the ways in which adult knowledge about learning is used.
- process knowledge or the method of inquiry in the subject. The process of designing and making which requires that children should devise and use a number of broad procedural strategies, such as generating ideas, communicating these ideas, making suggestions about how to proceed, and evaluating their products.

The present research aimed to concentrate particularly on the last aspect of this list to try to help students identify the problem solving strategies of professional designers and makers and link these to those of children in the classroom during activities on teaching practice.

A situated cognition perspective
A situated cognition stance was used in investigating how students might be initiated into the traditions of designing and making and explore how problem solving is dealt with by professionals. To inform this study, the works of Rogoff, (1990) and Lave (1996) view learning as a process of enculturation through shared activities into a community of practice. This literature seemed appropriate for the study as it is drawn from the professional practices of crafts people in the workplace, and focuses on problem solving for both experts and apprentices. It emphasises three essential aspects of design and technology activity. It centres on how the context of a task affects problem solving strategies, on students being inducted into a process such as design which draws upon industrial and cultural models, and on how the content of knowledge, skills and understanding of technological activity is both acquired by adults, and introduced to children.

In particular the work of Lave (1988) shows how problem solving strategies are devised and used by adults in everyday situations, and documents the technological apprenticeship of professional designers and makers. Inspired by the ideas of Giddens (1979), Lave demonstrates how personal and collaborative problem solving strategies are used successfully in the workplace, often without recourse to the methods taught in school. Lave (1992) bases her evidence on research done outside school, but believes that in school there is a tendency towards contrived problem solving, where teachers set highly specific aims requiring school type knowledge. She refers to the “chasms between school and everyday life” (ibid, p.76), and views both children and adults as lifelong learners, both in and out of school. Her work brings together problem solvers as diverse as ship navigators, doctors, blacksmiths and children in the classroom, and examines the contexts of their action and intention. In these portraits of everyday practice she acknowledges that adults and children may support each other as novice and expert. She is interested in how children and adult learners actively invent and make meaning in their learning in real situations.

Lave’s (1996) ultimate aim is to give apprentices control over their own learning processes, and confidence to engage in critical analysis, by both acknowledging their own intuitive strategies for problem solving, and passing on formal knowledge and skills that may be useful within the specific context. School and everyday knowledge are thereby both valued and linked within authentic problem solving.

It must be acknowledged that there are some problems when attempting to relate a situated cognition perspective and professional working situations to improved teaching and learning in the classroom. Most important is the problem of transfer of learning from one problem solving context to another. Recent researchers in design and technology education (Kimbell,1996; McCormick, 1996; Johnsey,1995) have moved away from the simplistic view that there is a single set of transferable procedures for designing and making in all situations. Strategies tend to be devised and differ according to the context of the particular problem. Moreover, even if students gain procedural knowledge from studio visits, it cannot be assumed that they will transfer problem solving skills and strategies from professional workshop to college context, and then to teaching in schools. Transfer of subject knowledge is too often taken for granted. A major question for this research was would students transfer the knowledge gained from professional designers and makers to college and classroom?

Another major question asked was whether professional procedural knowledge would be applicable to children in school. Johnsey (1998) points to the difference between children as design and technologists, professional designers, and design and technology by lay people. He emphasises the different contexts
addressed by professionals in the world outside school, and those devised for primary children by teachers, but enhanced knowledge of the subject gives teachers the confidence to encourage pupils to help set the contexts, and share control by negotiating tasks with the teacher. Johnsey (ibid) perceives that the professional designer has more freedom than children in school whose designing and making behaviour is modified by the presence of the teacher. However, professionals work within other constraints such as consumer demand, supply of resources, and economic considerations. The constraints of school structures are widely recognised and it has been accepted for some time that outside school children and adults invent their own procedures for solving problems and rarely use standard school methods (Suchman, 1987; Schulman, 1986). Similarly, school children often ignore formally taught methods and secretly use their own informal ones, so presenting a ‘veneer of accomplishment’ (Hennessy, 1993). These informal methods are often devalued in the school context. (Lave, 1988).

Data collection
The present research focused on 20 design and technology specialism students visiting six professional designers and makers at their places of work. The sample included male and female students of various ages and from a range of educational and employment backgrounds. All were graduates but their degree subjects varied from Art, Music and Science, to Fashion or Theatre Design. Some students came with relevant work experience, for example there was one former architect, and a film editor.

The data was collected as students talked with the professional makers, and worked within the academic and pedagogic framework of the design and technology specialism course. Data gathering sources included video footage, and transcripts of student interviews with professional makers in their studios. Students were asked to discuss topics such as current work in progress, and the usual processes of designing and making from the original idea to testing and marketing the finished product. Professionals were asked to focus on particularly challenging and interesting elements of previous projects, and conceptual and technical aspects of their work such as materials, tools, skills, knowledge and techniques, and safety factors. Students were asked to gather information on collaboration, organisational skills, business acumen and economic considerations, and were encouraged to discuss the professionals own background and training, and the personal and professional qualities that make a good design and technology teacher.

A second data source was the students’ written evaluations of their experiences with professional makers in their studios and workshops. These evaluations were completed after the visits and described in detail how they affected student understanding of design and technology, their attitude to the subject, and their own teaching in the classroom. Students were also asked to comment on how professional problems and strategies were similar to, or different from, their own when designing and making and those of primary children in schools, and also to comment on how the work of professional designers and makers might enrich the primary curriculum.

Student course work was a third source of data. This took the form of group discussions, notes, and plenary sessions. In these collaborative sessions students reflected upon their ideas about the design and make process and how it might be possible to create opportunities for children to develop their own problem solving strategies in the classroom. Student design and technology specialism assignments provided a final data source. In these written assignments which formed part of their final assessment students linked theory and practice to reflect upon pupils’ developing capability though creative problem solving and drew implications for their future design and technology teaching in the classroom.

Analysis
Qualitative data analysis was used in an attempt to gain insight into student understanding of the work of professional makers, and how this understanding might affect their own attitude to design and technology teaching in the classroom. Student evaluations, written assignments, and video transcripts, were analysed though the use of “critical incidents” (Woods, 1995). Discussing creative teaching in primary schools, Woods (ibid) defines a critical incident as a “highly charged moment or episode that has enormous consequences for personal change and development”. To illustrate this, he describes pupils in primary schools working with an author to publish a story book, children making a film about their village, and other occasions where additional adults have worked alongside class teachers to inspire both pupils and teachers to exceptional achievements. Anning (1996) describes Wood’s data collection as a rich mixture of
observations, interviews, videos and documents. She suggests that through his research methodology he offered “a medium through which teachers could express their views” (p.2, ibid). The work reported here hopes to offer a similar medium to student teachers.

The present study attempted to gain insight into how professionals responded to the challenges of designing and making, and what students learnt from this, through the identification and classification of critical incidents during student visits. Critical incidents were reflected in a number of data sources. A critical incident was defined as an incident or part of a discussion that had an obvious impact on student understanding in that it could be located in a video transcript and in student written work, but was also seen to have had an effect on student classroom teaching through lesson plans or schemes of work. Critical incidents could then be classified into categories or themes, which were perceived by the students as important for their own learning about problem solving processes and teaching.

Results
The critical incidents identified could be classified as those associated with:

Customer negotiation
Critical incidents concerned customer demand and negotiation. Professionals discussed how the final product often resulted from both the wants and needs of the consumer, and the interests and capabilities of the designer/makers. The client came with a product specification but it developed during negotiations between the client and manufacturer and there was a period of constant liaising. In this way there was a balance between satisfying what the client wanted but also raising their expectations concerning what they might have. The capability of the professional relied to some extent, not only on their knowledge and skills but on the constraints of the context, that is on considerations such as time, price, availability, and what professionals might perceive as the evolution and direction of their work. The impact of discussion about negotiation on student understanding and work in school was seen in their willingness to share with pupils the choice of design and technology assignments. It was also seen in their ability to allow scope for children to negotiate tasks with them during lessons on teaching practice. This often happened despite the constraints of the classroom context, for instance, space, time, and availability of tools and materials.

Planning and modelling
Although makers emphasised that designing and making were very much an integrated process there was a focus on planning processes identified by the research. The discussions between students and designers and makers often revolved around ways of approaching design such as creating industrial models and sketching. The students were particularly impressed by the professionals’ flexible approach to the planning process. Some professionals did not plan on paper, but used a variety of media to explore and express their ideas. A maker explained: “the design sort of grows, in an organic process during the making, rather than being planned on paper beforehand”. A consequence of this was students’ flexible attitude to pupil planning during design and technology lessons. Integrating the design process with making so that designing and making occurred spontaneously was seen as crucial by students on teaching practice. They encouraged pupils to research their own intuitive ideas for designing and there was a reluctance to insist that children plan on paper before they begin to make.

Resources
Critical incidents were associated with the materials and tools used by the designers and makers. In particular the inspiration of interesting materials, textures, functions and forms. Above all the notion that it was important for adult designers to be able to ‘play’ with materials, tools, and procedures within certain parameters, made an impact on the students. The fascination of materials was emphasised by one professional in particular who could distinguish five different blonde types of wood by characteristics of smell, touch and appearance. However, the risk of failure was also underlined by this professional, and the emotional aspects of experimentation and learning. It was explained that large scale projects were much more problematic than small because more was at stake and the economic pressures were greater. Students compared this with their own feelings and children’s mixed emotions as they begin to design and make. Many professionals emphasised the importance of self-confidence, trust in personal ability and a belief that problems can be solved through experience and expertise.
**Knowledge, skills, and understanding**

The students became aware of professional values concerning knowledge and skills. Major critical incidents revolved around the students’ awareness of the relationship between making and understanding. One professional had occasionally used her expertise to support teachers in schools. This automata maker spoke of the practical and intellectual link as children designed and made their own automata in the classroom. She explained “You have to actually teach basic mechanical principles through children making their own automata. When children actually physically make them rather than use kits they understand the principles better because they have to bend the crankshaft and shape the crank-slider, and it’s nice to see the penny drop when they realise how it works and why it works.” Thus, students began to see the essential relationship between hand and head that creates real understanding. They also appeared more open to pupils constantly exploring resources and investigating materials and there was a wider interpretation of the word ‘play’ and greater understanding of it as a strategy for life long learning. They began to see teaching as a balance between providing a focus for design and technology activity, while allowing space for individual exploration. They understood the value of teaching skills and techniques and of making this learning explicit to children so that they know their own talents and gain confidence and self-esteem.

**Collaborative teamwork**

Some critical incidents were associated with professional teamwork. Sharing knowledge of materials was highly valued. A furniture maker insisted, “You have to know how to treat each material, and it takes the weight off your mind to know that someone in the workshop has that specialised knowledge.” Professionals emphasised that the design and make process is often a collaborative effort, during their visits students were impressed by professional appreciation of both individual and group skills and were made aware of the contribution of a wide variety of experts who employed a range of talents. As a designer remarked, “We’re all in there mixing and solving problems together.” Consequently, the students seemed more aware of the benefits of collaborative practical activities for learning in general and of introducing professional crafts people into the classroom. Indeed many students used the contacts they had made with professionals on the studio visits to organise various forms of focused support for pupils in the classroom. They introduced school-based presentations, demonstrations, consultancy for specific projects and hands on sessions for pupils and staff. As one student commented they learnt “how an outside person could be an inspiring resource in school”.

**Conclusion**

The study examines how the student knowledge base may be extended through exposure to the traditions of designing and making which exist outside schools and colleges. It explores their beginning to understand how problem solving is dealt with in commercial and industrial situations and demonstrates how personal and collaborative problem solving strategies are used by professionals.

The research focused mainly on enhancing students’ procedural knowledge but in doing so had interesting effects. Students were inspired by the visits to increase their own content and pedagogical knowledge. One wrote, “learning a lot about the processes involved in designing and making made me want to increase my skills”, and another said, “gaining insight into how a designers mind really worked encouraged me to learn more”, others talked of processes and problem solving strategies being “demystified” by the studio visits. They also spoke of “being inspired to try out their new knowledge and skills in the classroom”. So that processes and concepts were inextricably linked and enhancing one kind of subject knowledge extended to the others.

Working with professionals also inspired other aspects of their work. Students appeared more inventive and creative in the classroom. They felt the impact of the studio environment for real innovation, and creativity. Reflecting this attitude, it seems that the recent review of the National Curriculum for design and technology, has moved towards a genuine desire to clarify how children develop capability and to “reorder the programmes of study in line with general practice” (DfEE, 1999). For the first time the Order describes children as “autonomous and creative problem solvers” (DfEE,1999). However, perhaps the most noticeable difference in past and new orders (ibid) is the view of primary children as discriminating consumers who understand “function and industrial practices”. This distinctive view of the contribution of design and technology to the school curriculum makes it a necessity that student teachers’ knowledge of the subject encompasses an understanding of professional designers and makers procedural knowledge.
References
DfEE (1999) *All Our Futures: Creativity, Culture and Education*, London: NACCC