# What do 'good' new technology teachers know?

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"I don't think anything quite prepares you for teaching in a class does it?"*(Technology student-teacher)*

***Abstract***

How significant is subject knowledge for creative and effective technology teaching? What links can be made between a teacher's knowledge and the associated pedagogic strategies and practices to ensure successful learning? In England and Wales, secondary teachers are required to have at least two years of their first degree in the subject they wish to teach. But what does this mean for technology teachers? Technology is well known for the breadth of subject knowledge it encompasses and the limited way in which degree courses provide for the scope needed for school technology. And is subject knowledge really so crucial? Might it not be better, in initial teacher education, to give student teachers a wider awareness of what knowledge might be needed for teaching rather than trying to focus on the need to 'plug gaps'? But what might the types and extent of that knowledge be?

At PATT-9 in Indianapolis, the authors reported on an empirical study conducted with technology student teachers from the Open University and Brunel University in the UK. It showed how a pictorial framework could help to represent the types of teacher professional knowledge and assist them to consider aspects of their classroom practice. We re-visit that work to consider further the empirical and theoretical basis for the framework, and also discuss a strategy for widening this study in an international collaboration known as the DEPTH project.

### *Introduction*

This paper discusses a study in the use of an explicit framework to assist new technology teachers to think about their practice. Student teachers used the framework in two very different institutions in the United Kingdom. This paper will:

- Illustrate the need for some means of making technology teachers' ideas about their professional knowledge more explicit
- Discuss the creation and formulation of the framework
- Consider the use of the framework in practice as a tool with technology student-teachers
- Outline the use of the technique in other countries as a means of investigating the extent to which technology teachers around the world share a common view of their professional knowledge.

### *Initiating the study*

Applebee (1989, p.217) notes that 'when we start to teach a new subject, one of the most powerful influences on what we do is our memory of how we were taught.' However, the relatively new subject of design and technology does not have a curriculum history long enough for those involved to have a common and shared 'memory' of how the subject 'should' be taught, as may be the case in science or mathematics. When they begin their courses, students have quite different 'personal subject constructs' about what they believe D&T education is for and how it should be taught, and come into the profession with quite different subject knowledge strengths. Establishing some shared agreement about what the categories of teacher professional knowledge may be will help student teachers reflect on their practice and facilitate the discussions between these new teachers and their more experienced colleagues.

> 'The 1991 national survey of all 317 initial teacher education courses in England and Wales […] revealed that over 70 per cent of those courses that claimed to be underpinned by a particular philosophy described that as being based on the principles of the reflective practitioner. […] Five years on, the term has achieved even wider currency, and the notion of reflectivity has become incorporated into many teachers' own view of what it means to be a professional' (Furlong and Maynard, 1995 p37)

There is little agreement, however, about what is meant by 'reflective practice' and Calderhead (1989) has described the notion as a slogan rather than a principle. We would agree with McIntyre (1993) that often a systematic approach to reflection is of limited value in the earliest stages of professional development where students have neither the time nor the breadth of experience to do more than experiment with the approach. However, we would strongly argue that such experimentation with reflection on practice would be more successful if the student is provided with a usable framework that will help them consider aspects of their professional knowledge in the widest sense.

This study was originally described as part of the PATT-9 conference. It was conducted as an attempt to evaluate how transparent different aspects of teacher professional knowledge are to student technology teachers, and to see how useful an explicit framework may be as a tool to help them construct a model of their own professional knowledge for reflection on that knowledge. However, we consider here in more detail the basis for the framework.

### *How do new technology teachers view their role?*

Bird et al (1993 p 254) report on the different ways researchers have characterised student teachers' beliefs about teaching:

> "as lay theories (Knowles & Holt-Reynolds, 1991), constructs (Mertz & McNeely, 1990), images (Calderhead & Robson, 1991), metaphors (Carter, 1990), and webs (McDiarmid, 1990)"

Of these Calderhead & Robinson (1991) in their study pay particular attention to the students' images of the "good" or "bad" teacher as being of particular significance. However, Design and Technology has been dubbed a subject designed by committee (see McCormick 1990). So just what sort of teachers do these students think about? The first national curriculum order in England and Wales attempted to bring together contributions from the subject areas of art and design, business studies (BS), 'Craft, Design and Technology' (CDT), Information Technology (IT) and Home Economics (HE). The rationale for this was an assumption that these subjects share a common base of procedural knowledge (knowing how) and could each contribute specific aspects of propositional knowledge, (knowing that). There is no unambiguous agreement as to what technology is, however, and many teachers had to work out the rationale for the subject by themselves.

The difficulties experienced by teachers can to some extent be gauged by looking at the range of publications produced between 1989 and 1995 aimed at clarifying the situation for the teacher. These included a complete revision of the National Curriculum Orders for Design and Technology (D&T) (See Barlex 1998). One of the aims of the D&T curriculum in England and Wales is to provide a broad and balanced experience of designing and making using a range of materials and technical components.

> Pupils should be given opportunities to develop their design & technology capability through:
>
> a) Assignments in which they design and make products, focussing on different contexts and materials and making use of:
>
> - Resistant materials;
> - Compliant materials and / or food.
>
> Taken together, these assignments should include work with control systems, *e.g. electrical, electronic, mechanical, pneumatic,* and structures;
>
> b) focused practical tasks in which they develop and practise particular skills and knowledge;
>
> c) activities in which they investigate, disassemble and evaluate familiar products and applications. (DFE / WO,1995, p6)

However, there is more to this breadth and balance than merely the materials and components used (See Barlex, 1995). Within the designing and making process there are features which will appeal to different degrees to a teacher according to the specialism and professional history of that teacher. Teachers will have greater familiarity with and preference for particular areas. The list below identifies such features and the often-articulated rationale for its significance. The difficulty in achieving breadth and balance arises when that significance becomes instead dominance:

| | |
|---|---|
| • Aesthetics | The appearance is crucial. It says everything about the product. |
| • Communicating skills | Unless they communicate their ideas nothing will be accomplished. |
| • Design procedures | Without the procedural competence of design |

| | |
|---|---|
| | nothing can be achieved. |
| • Making skills | But if they can't make it it's a complete waste of time. |
| • Technical understanding | If it's not technically sound it just won't work. |
| • Values | Without an appreciation of the values implicit in the endeavour the whole exercise lacks worth |

Fig 1 Features of Design and Technology education.

Ideally a balanced designing and making assignment will call on each of these features if not in equal measure then certainly to a significant extent. But, if a teacher is strong in just one or two aspects, or believes that one is more significant than any of the others, the breadth and balance within the designing and making experience is lost. Many technology teachers were trained initially as craft teachers and their work has been generally criticised by the Office for Standards in Education (OFSTED).

> ". . . .in general pupils' attainment in designing lags behind that in making. This is because pupils are either not introduced to a sufficiently wide range of designing strategies [...] or are not taught to use them effectively. Pupils are generally confident where work is closely directed by the teacher, but less so when working independently to their own plans, with little awareness of how their work will develop in the later stages of their projects." (OFSTED, 1998)

Clearly there is the possibility, if not probability, that student teachers in school based training will be introduced to practice that is skewed because of the previous history of the supporting teachers in that school.

> When I first looked at technology, I thought the design process would be a very important part along with the design I have done in the past. But as I have been in school, I don't see the design process being as important as I thought it was going to be. In a lot of classes it's put on the back-burner and they're told what they are going to make and that's it. What I have seen is more skills based than design based. (Julia OU student)

> I am not sure that the people who drew up the curriculum orders know what technology is for. So I am still uncertain. I can see the importance of imparting skills but I would have thought that the main reason is that people firstly come more aware of the technology around them and secondly to appreciate design to fit a particular purpose. And I am not sure how you do that and still facilitate the teaching of skills. (Mick OU student)

Philippa also found a contradiction between what she saw as being important in the subject and the classroom reality of putting that into practice:

> I mean for me, designing and understanding about design is just through experience of doing it and going through college and design being my major subject there, it was always the big mystery of what made the good designer. In many ways just being aware of as many constraints as possible and having the confidence of thinking that you could come up with some solution, and I think that comes with a lot of experience. That's why I think that when we are dealing with year 7 there is a great difficulty with coming to terms with the notion of designing. I think they're not brought up to it. It doesn't figure strongly in our education up till then and I think it's very hard to introduce it to them. (Philippa OU student)

In an attempt to help new technology teachers find a way though this muddled curriculum, with a variety of methods all seen as 'good' practice, we considered the use of a pictorial framework which attempted to make concrete the various and conflicting aspects of teacher professional knowledge. The greater involvement of schools in the professional development of new teachers makes it increasingly important to establish a common framework of understanding between students, school staff and lecturers in higher education. School-Higher Education Institute (HEI) partnerships have existed for years, but an increased use of subject 'mentoring' in initial teacher education means it is useful to also extend our common understandings to a fuller discussion of the different components which make up teacher professional knowledge.

### *Creating a framework for conceptualising teacher professional knowledge*

Since 1995, our colleagues in the Centre for Research and Development in Teacher Education (CReTE) at the Open University have been developing a pictorial model of teacher professional knowledge (see Leach and Banks, 1996; Moon and Banks, 1996; Banks, 1997a; Banks, Leach and Moon, 1999). To do this, they observed student teachers of both English and Design & Technology, interviewed them, and discussed their understandings and how that related to their perceptions of colleagues in school.

The model also built upon the work of others. Since the mid-1980s there has been considerable discussion and a growing body of research on the forms of knowledge required by teachers in performing their role (Shulman and Sykes 1986; Shulman 1986; Grossman Wilson & Shulman 1989; McNamara 1991). These different forms of teacher knowledge have been usefully summarised by McNamara (1991, p.115), and we present them in an adapted form here:

*Subject Content Knowledge*

Design and technology is a very broad subject. However, teachers need to have a good understanding of a substantive part of their subject to serve their pupils properly

- If the aim of teaching is to enhance children's understanding then teachers themselves must have a flexible and sophisticated understanding of subject matter knowledge in order to achieve this purpose in the classroom.

The understanding of subject must be 'flexible and sophisticated' to include the ways in which the subject is conducted by academics within the field, 'to draw relationships within the subject as well as across disciplinary fields and to make connections to the world outside school' (McDiarmid et al 1989, p.193)

- Teachers' subject matter knowledge influences the way in which they teach, and teachers who know more about a subject will be more interesting and adventurous in their methods and, consequently, more effective. Teachers with only a limited knowledge of a subject may avoid teaching difficult or complex aspects of it and teach in a manner which avoids pupil participation and questioning and which fails to draw upon children's experience.

*Pedagogical Knowledge*

This knowledge is often given labels such as 'subject application' in DFE documents (DFE 1992, DfEE 1997, 1998). We use here the term 'pedagogical knowledge' after Lee Shulman (1986)

- At the heart of teaching is the notion of forms of representation and to a significant degree teaching entails knowing about and understanding ways of representing and formulating subject matter so that it can be understood by children. This in turn requires teachers to have a sophisticated understanding of a subject and its interaction with other subjects.

Shulman states:

> 'Within the category of pedagogical content knowledge I include, for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations - in a word, the ways of representing and formulating the subject that makes it comprehensible to others.' (Shulman, 1986)

Since the early 1990s there have been at least four published schemes for teaching national curriculum Design and Technology (Staffordshire Technology Education Project (STEP), Nuffield D&T (at both primary and secondary levels), the Technology Enhancement Project (TEP) and the Royal College of Art Schools Technology Project (RCA)). All teachers need to be aware of these and other curriculum materials and resources

- Knowledge of subject content is necessary to enable the teacher to evaluate textbooks, computer software and other teaching aids and mediums of instruction. This is the *materia medica* or *pharmacopoeia*, as Shulman puts it, from which teachers draw their equipment that present or exemplify particular content.

*School- Subject Knowledge*

To these types of teacher knowledge we would wish to add ‘school-subject knowledge’ (see Banks et al 1999, Banks and Barlex 1999)

- By altering technology to make it accessible to learners, a distinctive type of knowledge is formulated in its own right - ‘school technology’. In the same way that school science has differences from science conducted outside the school laboratory, so school D&T is different from technology as practised in the world outside the school.

One might initially see 'school knowledge' as being intermediary between subject knowledge (knowledge of technology as practised by different types of technologists for example) and pedagogical knowledge as used by teachers (‘the most powerful analogies, illustrations, examples, explanations and demonstrations '). This would be to underplay the dynamic relationship between the categories of knowledge implied. For example, a teacher’s subject knowledge is enhanced by his or her own pedagogy in practice and by the resources which form part of their school knowledge. Which teacher has not confessed to only really understanding a topic when they were required to teach it to others! It is the active intersection of subject knowledge, school knowledge and pedagogical knowledge that brings teacher professional knowledge into being.

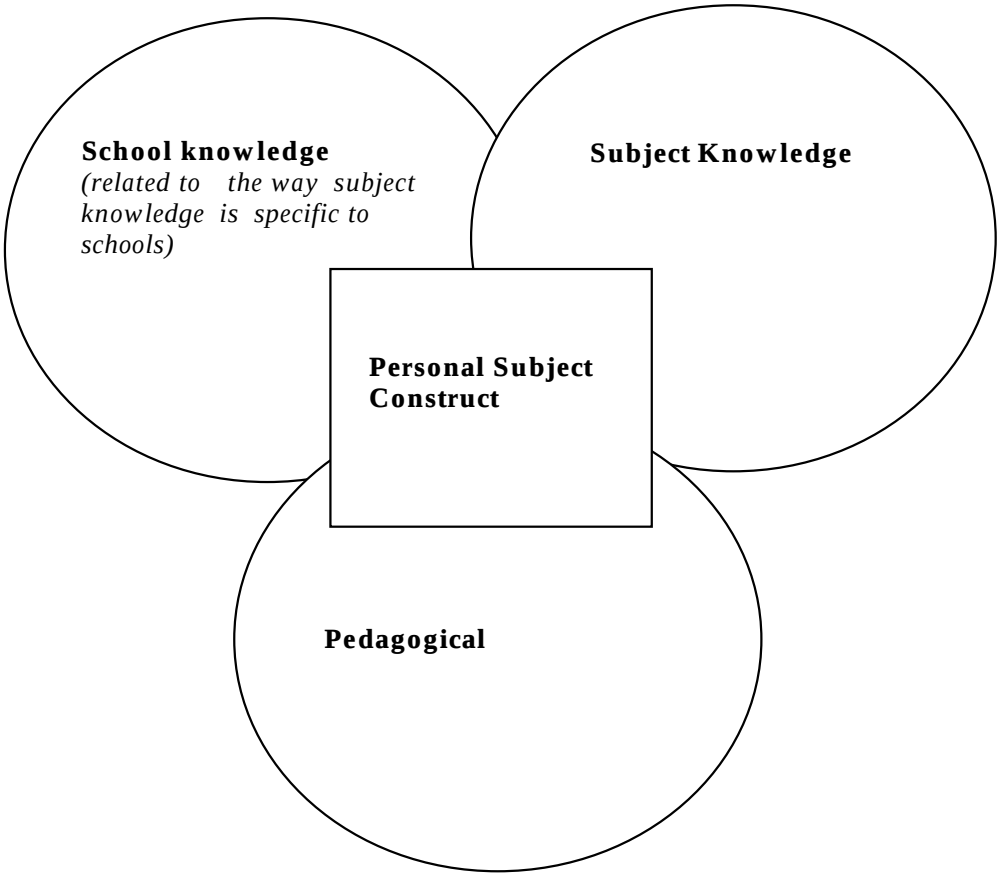


Figure 2 'CReTE' Framework of Teacher Professional Knowledge

Lying at the heart of this dynamic process are the 'personal constructs' of teacher and pupils, a complex amalgam of past knowledge, experiences of learning, a personal view of what constitutes 'good' teaching and belief in the purposes of the subject. This all underpins a teacher's professional knowledge. This is as true for any teacher. A student teacher has to question his or her personal beliefs about their subject as they work out a rationale for their classroom behaviours.

The diagram has some similarities with the developmental model of 'pedagogical content knowing' proposed by Cochran, DeRutter and King (1993), but is simpler in form.

### *Process versus Product*

This pictorial framework, developed at The Open University, was used as the working tool for reflection. But a tool such as this is more than just a means to an end. The means is, perhaps, more important than the end. Shulman's analysis is an important and fruitful starting point, but we see it as offering only partial insight into the complex nature of subject expertise for teaching. We are critical in particular of the emphasis on professional knowledge as a static body of content, lodged in the mind of the teacher. Shulman's work is informed by an essentially objectivist epistemology. In this tradition academic scholars search for ultimate truths, whilst teachers merely seek to "make that privileged representation accessible to ordinary mortals" (McKewan and Bull, 1991). Pedagogical content knowledge thus defines the subject specialists' task as that of discovering:

> "the most useful forms of analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject" in order to make it "comprehensible to others." (Shulman, 1986, p.6).

As such Shulman's work not only leans on a theory of cognition that views knowledge as an external body of information but also on an essentially teacher centred pedagogy. Other ideas such as the work of Gardner (1983,1991) on multiple intelligences, the work of Verret (1975) and Chevellard (1991) on didactic transposition and finally, Lave's (1988; 1991) research with adult learners were critical to our notion of the diagram as something developmental and not 'fixed' final or 'correct'. (See Banks and Barlex, 1999 for a fuller discussion of these ideas)

In practice, the discussion of what is appropriate for different parts of the diagram and the relationship between the circles helps with reflection on practice more than any completed picture ever could. The process of thinking initiated by the diagram is more important than the diagram itself. Similarly a completed diagram such as figure 3 can engender considerable debate and further reflection on practice in explicit terms.

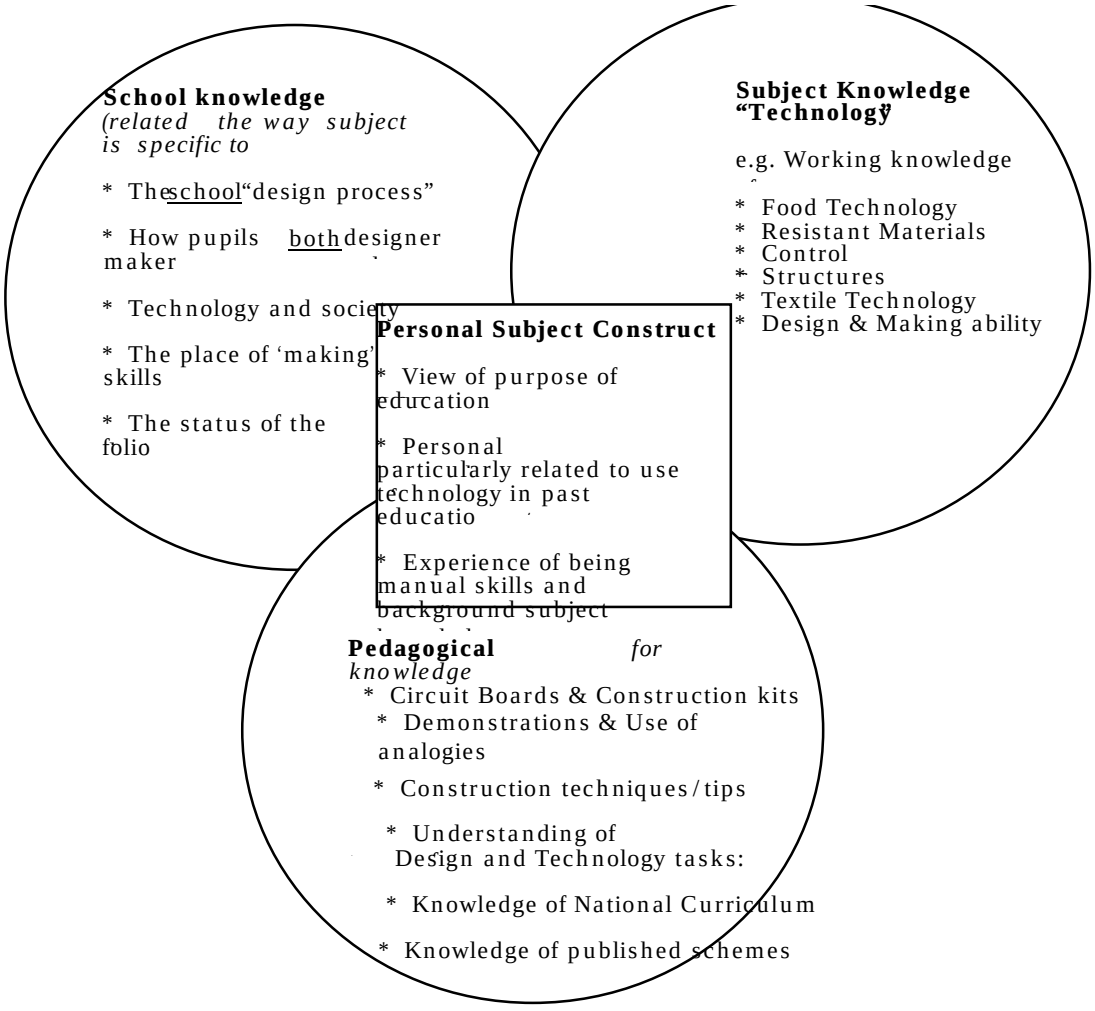


Figure 3 A completed diagram

### *Using the framework in practice*

Thirteen technology student teachers in the final year of their course from the Brunel University and the Open University were interviewed and shown a blank outline of the CReTE framework (Fig 2). The different elements of the framework were explained to them and, in relation to the work on teaching placement, they were asked the following:

- What subject knowledge (about D&T) do I have / need to get for the teaching?
- What pedagogic knowledge (about teaching methods) do I have / need to get for the teaching?
- What school knowledge (about ethos, procedures, significance of some activities) do I have / need to get for the teaching?

The students were also asked to consider their 'personal subject construct' as outlined above.

The Open University student teachers gave their views verbally and their points were noted onto the blank diagrams. The students from Brunel University were asked to produce a short piece of writing 'in which you reflect on some teaching that you did in your last practice in which you can comment on each of the three features'.

### *Results*

As might be expected, the students used the framework with a range of levels of sophistication. For all students it provided a useful focus for debate, and in particular the nature and extent of school knowledge was discussed by the Brunel students using figure 2. The views of seven students who either contributed a piece of writing or made significant comments are included here.

#### School knowledge

First, some ideas about 'school knowledge':

James: It is important that I discover the expectations within the department [...] This may be as pedantic as the layout of work, something I perhaps may not entirely agree with, but [...] something they gain marks for after I have left, then they will be required to be familiar with it. My own teaching can then work around this.

Frank: After a few weeks within the department I noticed that the department ethos, or approach to teaching was the same across the board. [...] The projects from year 7 upward were very closed in nature and pupils were led by the hand through each assignment. This resulted in the pupils producing an end product identical to everyone else. I must admit it was to a high standard and I learned a lot about subject knowledge, especially in the area of woodwork practices and processes. It seemed to me that the department was setting Design and Make assignments that were in fact Focused Practical Tasks.

Karen: After working in [...] it is very easy to figure out what the subject teachers are like and the commitment to the school and pupils. The following points are things to look out for in the next school.

Karen goes on to list 23 bullet points. All but two we would classify as 'school knowledge'. She 'looks out' for wall displays, exam results, attitudes of the pupils and teachers, schemes of work and a range of school polices such as SEN, homework and detention.

Christopher: In school you have to work in a particular way. For example the control software package configures the way I have to work and the pupils have to think because that is recommended by the exam board.

Vincent: In this school the department is driven by the exam. That is all that is important. So I think technology here is too individualistic where industry is social.

## Subject knowledge

All the students could identify subject knowledge gaps that they had. Indeed the rectification of technology subject gaps is a pre-occupation on many teacher preparation courses at all levels (see Banks 1997b) The Open University students in the sample were working as school technicians and felt relatively confident:

Colin: There is no 'big hole' in my knowledge due to being a technician but sometimes I forget the 'easy stuff'!

Competence in 'Graphics' was a declared problem for three of the students. Two of them said that they lacked sufficient knowledge of electronics for more than basic work.

Frank: I knew I was lacking in some of the graphics subject knowledge, so I spent a great deal of time and effort getting up to scratch on them.

### Pedagogical knowledge

Vincent and Christopher had a clear view of how the pupils' enthusiasm for technology and the quality of their work was intimately bound up with the teaching strategies deployed.

Vincent: Pupils take their cue from the teacher. There is a lot of 'street cred' for the subject in this school – more so than Art – but it is just as creative. However, there is very little group discussion used.

Frank: During my last school practice I worked with a Year 10 Graphics group. I found this group to be very passive and generally switched off to the subject. [...]. There was a lack of imagination being demonstrated in their work, which I felt, was coming from the way the subject was being presented to them. [...] I introduced group-work, which they had not experienced in D&T and let them give their opinions. We explored ways we could use these skills in presenting what we wanted to say in graphics. [...] The pupils responded very well and produced many varied and imaginative results. In addition [...], I set a competition to produce a graphic image. This was very open, with the only criteria being that it was interesting to the eye or not as the case may be. This really was difficult for the pupils to take on board initially, as they wanted to know what I wanted as a result. In the end they produced a very good series of images, some 3D, some computerised, some with

alternative backgrounds. The approach to teaching in a different way from chalk and talk seemed to awaken this group of pupils.

Khan: I felt that the pupils required a change of task setting and a more 3D approach to graphics. [...] I allocated time for the pupils to create prototypes or models from cardboard of the designs they had generated and present their museum designs, through their graphics based work and models to a board of directors (the rest of the class) therefore relating the project to real life contexts of designing in society. I left the presentation styles up to the individual pupils but did incorporate some input [...] on presentation techniques using computer graphics and boards. It was expected that the pupils would give a 2-3 min presentation. The end result was a positive change of all the attitudes of the pupils. They exhibited a general willingness to learn and an interest not only in their own work but others, especially the presentation where the pupils generated constructive criticism and reacted well to others discussing their work.

Personal subject construct

The nature and quality of the answers showed the range of personal subject constructs held by the student teachers and they often mentioned how it conflicted with construct held by their school mentor or other people in the school technology department. Vincent, like Kahn in the quote above, saw technology as being closely linked to 'real-life' and vocational preparation. Christopher, in contrast, saw technology as empowering for the pupils. They should understand 'how to wire a plug and not be scared to do things'. He wanted pupils to 'have a go'.

### *Summary*

It is significant in that the students across two quite separate institutions, with students from very different parts of the UK, could identify with the concepts outlined in the CReTE framework. It is clear from the above extracts and examples that they could use the categories as a means to reflect on their practice. The investigators could, in turn, use the diagram as a way to group aspects of teacher knowledge when the students described both their own practice and that of their colleagues in school.

### *An International Study*

Does such a framework have a possible use wider that the UK context? Is this formulation of teacher professional knowledge rooted solely in a conceptualisation of teaching which is rooted in an English, even Victorian tradition? The framework has been used at a number of in-service events throughout the UK and in other countries such as South Africa, Sweden and the Netherlands and many teachers have also been sympathetic to the model and how it matches on to aspects of their real-life practice.

*DEPTH project*

Following a presentation of these ideas at the PATT-9 conference in Indianapolis in March 1999, a collaborative project known as **DEPTH** (**De**veloping **P**rofessional **Th**inking for Technology Teachers) was established.

It has the following aims:

- To use a common technique internationally to investigate technology teacher professional knowledge
- To discover differences and similarities in the perceptions of trainee technology teachers as to what is significant professional knowledge

- To identify factors which affect technology teacher professional knowledge
- To investigate the usefulness of DEPTH as a model for international collaboration in research into teacher education and training.

Phase 1 of the project is a replication in University education departments around the world of the work already done in the two, very different, UK institutions. Colleagues taking part in Phase 1 are listed in the appendix. Using the CReTE framework, student teachers are encouraged to identify those aspects of teacher professional knowledge that they feel they possess. Further, they are introduced to the notion that their previous experience and beliefs have an impact on their view of what is and is not important in technology education. An interesting outcome will be the similarities and differences that may be revealed.

Phase 2 will be an analysis of the outcomes from phase 1 and, following a refinement of the methodological aspects of the work which will no doubt be necessary due to the different local contexts, a further round of investigation. The participants hope to come together to share their experiences at ITEA / PATT-10 in Salt Lake City in April 2000.

The positive impact on pupil learning in technology due to student teachers that are better able to reflect on their practice seems clear from the results presented here. As McIntyre (1993) suggests, reflection by novice teachers is very difficult. However, we believe that this study has shown the framework is a simple yet effective 'way in' to begin the discussion of the different aspects of teacher knowledge. We hope the DEPTH project will take this wider to see if there can be more general insights into the various aspects that contribute to the professional role of an effective technology teacher.

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### *Appendix*

Current members of the DEPTH project:

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|---|---|---|---|
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| John | Williams | Edith Cowan University | Australia |