Subject knowledge content in primary initial teacher education courses in design and technology – a discussion paper

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Abstract

A rationale for the development of appropriate subject knowledge content of the design and technology component of new Initial Teacher Education courses is presented, indicating that substantive, syntactic and pedagogic content knowledge, knowledge about the management of learning and distinctive aspects of the subject are key elements which should be investigated. Given the tight time constraints on the delivery of courses, priority should be given to areas which

- illustrate the range of syntactic or process knowledge of the subject
- ensure a knowledge of the concepts underpinning the National Curriculum
- are known to be frequently deficient in students' own knowledge
- are known to present particular challenges in teaching and learning. Preliminary findings from a pilot study into teacher's perceptions about aspects of subject knowledge highlight areas of design and technology that are perceived as conceptually difficult to understand and/or manage.

Introduction

Circular 14/93, The Initial Training of Primary Teachers (DfE 1993), challenges Initial Teacher Education (ITE) institutions with the requirement to:

- develop courses that will support effective teaching
- design and deliver courses in partnership with schools
- assess students against teaching competencies.

Whilst the circular emphasises a diversity of provision within primary ITE, it is likely that economic pressures will drive students and hence universities towards three-year B.Ed. courses (which can expect to face rigorous competition from the Open University). The time pressures on B.Ed. courses will necessitate extremely focused subject elements in order to provide high quality teaching and learning, demonstrate academic rigour and, where appropriate, satisfy honours validation requirements. These pressures will mirror those currently being felt by PGCE courses, which have sought to promote confidence and competence in the short time scale allocated for initial teacher education. Indeed, the subject elements of any ITE course will need to have a clear rationale for content in order that students develop the required competences.

The circular lays great stress on the development of subject knowledge as a key element of these competences. Thus the need for a clear rationale for the development of subject knowledge within courses and the choice of content of those courses has never been stronger. Against a background of research into subject knowledge and teacher effectiveness, this paper will seek to present such a rationale for the design and technology subject element of ITE courses and, based on that rationale, propose appropriate content for such courses.

Subject knowledge and effective teaching

The value of subject knowledge in the promotion of high quality teaching is becoming more fully appreciated beyond the axiomatic dictum that, 'you can't teach what you don't know.' Kennedy (1991) stresses the importance of enough understanding to separate the key elements of a subject in order to realise how different ideas relate to one another and how they can be represented to pupils. Grossman et al (1989) report from case studies of secondary student teachers that familiarity with subject knowledge affects what is taught and how it is taught. Student teachers with subject specialist knowledge were more likely to stress conceptual understanding and syntactic knowledge in their teaching, whereas non-specialists tended to teach in a more prosaic manner, stressing content as it was represented in teaching texts with little or no discussion. McDiarmid et al (1989) found that teachers' capacity to pose relevant questions, select

appropriate activities and evaluate pupils' understanding were all dependent on their understanding of the subject under study. Teachers were better able to enable pupils to develop a flexible understanding of subject matter if they had mastery of subject knowledge.

This evidence is based on research in secondary schools. The need for subject knowledge at primary level has been stressed by Alexander et al (1992), who insist that teachers should be able to employ their subject knowledge so as to ensure that their teaching stretches pupils' thinking and 'not merely keeps step with it.' The lack of tradition of specialist subject teaching in primary schools has meant that there is a dearth of research into this area at Key Stages 1 and 2. Bennett and Turner – Bissett (1993) provide case study evidence from observation of primary PGCE students' teaching that lack of subject knowledge appears to exhibit itself in less intellectual output and more classroom management. Whilst recognising that high quality teaching requires high quality management, they highlight the key role that subject knowledge plays in informing teacher intentions, the organisation and representation of knowledge and the quality of teacher evaluation and reflection. A research project currently being undertaken at the Brunel University School of Education by Jeffrey et al (1996) is attempting to shed further light on how subject knowledge can influence teaching in the primary classroom.

What subject knowledge?

Schulman (1986) has identified seven subject knowledge bases as necessary for effective teaching:

- content knowledge
- general pedagogical knowledge
- curriculum knowledge
- pedagogical content knowledge
- knowledge of learners and their characteristics
- knowledge of educational contexts
- knowledge of educational ends, purposes and values.

Ellis (1995) builds upon these in an attempt to provide a rationale for the content of new ITE courses. This analysis may be summarised for course planning purposes as comprising:

- *substantive content knowledge* – the facts, skills and concepts of a subject, together with its explanatory and organisational frameworks
- *syntactic or process knowledge* – the methods of inquiry in the subject and demonstration of how knowledge is generated, tested and justified
- *distinctive aspects of the subject* – those beliefs and values associated with the subject, the history of the subject and its role in modern society, controversial aspects of the subject, the subject's relationship to and epistemological difference from other subjects
- *pedagogical content knowledge* – aspects of the subject which relate to teaching and learning, including knowledge about learners, the ways in which adult knowledge is used in teaching and knowledge of the appropriate means of assessment and evaluation
- *knowledge about the management of learning* – knowledge of materials and resources, organising learning environments and working with other teachers.

Given the depth and breadth of subject knowledge to be covered and the time constraints imposed on the delivery of new ITE courses, decisions have to be made about which elements of the above should be included on any course at this initial phase of professional development. Ellis (ibid.) offers the following criteria for the selection of content, proposing that priority should be given to content areas which:

- illustrate the range of syntactic or process knowledge of the subject

- ensure a knowledge of the concepts underpinning the content of those topics which appear in the National Curriculum
- are known to be frequently deficient in student's own knowledge;
- are known to present particular challenges in teaching and learning.

It is proposed that these criteria can form a platform for decision making about the content of design and technology subject elements on ITE courses with a view to fulfilling the substantive, syntactic and pedagogical content knowledge and knowledge about the management of learning and distinctive aspects of the subject necessary for effective teaching and learning.

Subject knowledge in design and technology courses

Content areas which illustrate the range of syntactic or process knowledge of the subject

One major challenge with regard to syntactic knowledge is to develop students' own design and technology capability and an understanding of the balance and interplay between the active and reflective elements of that capability. One way of effecting this would be for students to engage in a substantial design and make assignment at their own level in order to gain a critical appreciation of the process of design and technology, the cross-curricular nature the subject and the subtleties of action and reflection involved in designing and making. Such activity could also inform students' substantive knowledge – for example, students engaged in designing and making mechanical toys would learn about control, mechanisms, structures and types of movement (O'Hara and Noble 1995). There would be a need on the part of tutors for an awareness of the need to develop students' capability to the full. This would necessitate an initial assessment of the students' 'level' of capability, supported by a sensitive appreciation of some students' possible lack of confidence and perceived competence in designing and making, in order to develop and maintain positive attitudes towards the subject.

However it is recognised that, of itself, such activity would not fully equip students with the ability to successfully develop capability in children. Understanding of capability would need to be complemented by an awareness of the means by which knowledge can be successfully represented to and understood by children. To foster this, it would be necessary for students to gain an understanding of pedagogical content knowledge with a particular focus on how children learn from engagement in the process of designing and making. This would, of necessity, involve an analysis of the ways in which children learn from practical activity, the means by which they actively construct their own understanding of the world around them and the importance of the social context of learning (Ritchie 1995).

Such study would be incomplete without an inquiry into those elements of subject knowledge which epitomise the distinctive nature of design and technology – values associated with the subject, the central role of evaluating, the relationship and distinction between design and technology and other subjects (including maths, science, art and design and information technology), and the impact of technology on modern society and the environment.

Controversial aspects of the subject could be explored through an investigation into the history of design and technology as a National Curriculum subject, incorporating an analysis of the extent to which design and technology has been perceived and interpreted as a problem identification/solving process as distinct from a means for the designing and making of products and the problems encountered in attempting to explain the complexities of designing and making in simplistic or formulaic terms.

Knowledge of the concepts underpinning the content of those topics which appear in the National Curriculum

The historical analysis of the recent development of design and technology as a subject can lead to a better understanding of the rationale for the content of design and technology at Key Stages 1 and 2. This

content is succinctly documented in the statutory order.

It would be necessary to draw attention to specific aspects of the Programmes of Study in order to develop students' understanding and capability. One such aspect might be the use of materials. This could take the form of a critical analysis of Fulton's (1992) excellent treatise on the way in which the exploitation of the properties of materials has shaped the evolution of the human species and has had a profound effect on the development of human culture and civilisation. Such an analysis could serve to highlight the influence of design and technology in the development of the structure of thinking and act as a catalyst for preventing the marginalisation of the subject at primary level (Breckon 1995). This would need to be complemented by a practical understanding of the particular working characteristics of materials and how they can be used in an appropriate manner by young children in their designing and making. The benefit of such an approach is that not only would it lead to a deepening understanding of a distinctive element of design and technology, but also an awareness of how that understanding might inform work in practical teaching contexts.

Content areas which are known to be frequently deficient in student's own knowledge

There is limited research in this area with regard to design and technology, but research in other areas, such as science, indicates a lack of adequate subject knowledge in student teachers on entry to courses. Carre (1993) found that graduates on entry to primary PGCE courses had limited understanding of the substantive and syntactic knowledge of science needed to teach at primary level. This included substantive knowledge about forces and energy. These are areas of knowledge which are important for teaching elements of design and technology, although it is recognised that energy is no longer an explicit requirement in the Science National Curriculum at Key Stages 1 and 2.

This lack of understanding of areas of substantive knowledge in science of direct relevance to work in design and technology extends to practising teachers. Kruger et al (1988) present evidence of teachers holding views of concepts about energy, forces and materials that are not in accord with generally accepted scientific interpretation, denoting problems with concepts needed for effective teaching.

These findings highlight the need for research with regard to students' (and teachers') substantive knowledge about such areas as mechanisms, control, structures, materials and also food technology. A more accurate picture of knowledge (or lack of it) in these areas could form the basis for devising teaching and learning materials geared towards ascertaining and building upon understanding.

Content areas which are known to present particular challenges in terms of teaching and learning

The author is currently engaged in researching this area. Limited pilot study informal interview and questionnaire evidence from teachers in university partnership schools and participants on GEST courses have indicated that teacher concerns can be resolved into three categories – those elements which are perceived to be conceptually difficult to understand, those which pose challenges in terms of management and those which are new to the curriculum.

Areas perceived as conceptually difficult to understand – elements of substantive knowledge concerning control, mechanisms and (to a lesser extent) structures, involving scientific concepts such as energy and force were prominent in this category.

Syntactic knowledge elements such as understanding the principles involved in developing realistic design proposals and evaluating were also seen as difficult – indeed developing design and technology capability was (rightfully) seen as a complex area involving a subtle understanding of how children actually go about, as one teacher stated, 'turning ideas into products.'

This perceived conceptual difficulty may have been caused by or at least

compounded by the fact that very few of the teachers interviewed had extensive scientific or technological experience in their own schooling.

Areas perceived as difficult to manage – the development of children's manual skills was cited as being challenging to manage. The need to teach specific skills to individuals or small groups was seen as particularly forbidding in terms of time management and whole class organisation. There were particular concerns about the health and safety implications of such activities as the use of food and resistant materials.

Time management was cited as a genuine source of difficulty in the assessment in design and technology. The problem of carrying out assessment was compounded by some teachers' professed concerns over their lack of understanding of design and technology capability and the difficulties of assessing groups of children engaged in practical activity.

Management of resources was also seen as problematic, particularly in those areas requiring specific resources which need careful maintenance, such as construction kits. The problem of lack of resources was frequently cited. A recent survey indicating a capitation allowance of £1.44 per pupil in 1994/95 confirms the current low level of funding for design and technology in primary schools (Design and Technology Association 1995).

New areas – as a new area, products and applications was seen as not necessarily being difficult per se, but a potential source of vulnerability because of unfamiliarity, with a consequent perceived lack of personal knowledge and understanding – the typical comment being, "If only I had the time to find out what these things really involve and how I could teach them."

Another relatively new development, the use of information technology, posed particular challenges in terms of management, access to resources and conceptual difficulty (one example cited being the use of computers for control).

These perceived difficulties indicate a need for developing substantive and syntactic knowledge and knowledge about the management of learning. It is tempting to suggest that many of the above difficulties could be resolved by investment in in-service training and the use of Dearing's 20%, but this panacea is undermined by inadequate funding for design and technology and primary education as a whole. A higher profile for design and technology in ITE may be one realistic step forward in attempting to address some of these issues, incorporating an imaginative exploitation of partnership arrangements with schools.

Conclusion

It should be stressed that the elements proposed are by no means presented as a complete picture of areas that should be covered within design and technology subject studies – on such grounds the proposals could be criticised for being incomplete (for example, how might students reach an understanding of developing equal opportunities within the subject; how would heath and safety issues be addressed?) Rather the intention has been to propose a rationale upon which informed choices might be made about the subject knowledge content of courses. It is also recognised that there are important issues for consideration which are beyond the scope and remit of this paper, such as the role of school experience and the impact of ITE subject study courses on teaching (Bennett and Carre, 1993). Such matters are deserving of sustained analysis and evaluation if we are to deliver ITE courses of quality and relevance.

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