

FOSTERING THE PRACTICAL IMAGINATION: PERSONAL PROJECT WORK, LEARNING, AND HIGHER-ORDER THINKING

Dr Bridget A Egan, University of Winchester, WINCHESTER, UK SO 22 4NR

The notion of reflexivity is widely canvassed as a key skill for both teachers in developing their professional practice and for learners in developing metacognitive structures and strategies (Schon: 1983; Ghaye & Ghaye; 1998). Doucet & Mauthner point out that 'the difficulties, practicalities and methods of doing it are rarely addressed' (2003: 413). The question thus arises of how best to foster reflexivity in learners, and particularly in learners who are also in the process of becoming teachers. In my institution, the development of reflexivity as a key skill for young teachers is seen as highly important. Students are encouraged to maintain a range of personal records, including a 'learning journal'. In reality, only a minority in fact do this. Finding strategies that enable reflection as a part of ongoing course activity thus becomes an imperative.

This paper reviews the learning of a group of non-specialist student teachers taking an optional module in design and technology, through self-directed practical projects in which the tutor acted as facilitator and skills supporter rather than mentor. It demonstrates a number of aspects of the outcomes for the students. Data from students' reflective writing evaluating their own learning through the project and their reflections on work undertaken in schools with children is analysed. The analysis draws upon Howard Gardner's (1983) theory of multiple intelligences, Kieran Egan's (1997) typology of cognitive tools, and the work of a number of design educators (Archer & Roberts: 1992; Archer: 1992; Baynes 1992 & 1994; Kimbell, Stables & Green: 1996) to explore the relationship between self-directed practical activity, personalised learning, and reflexive thinking skills.

Context

The introduction of the first version of a National Curriculum for England and Wales between 1990 and 1991 (as different subjects were phased in), was prefigured in the UK's Education Reform Act of 1988 (ERA). In many respects, the National Curriculum brought little that was completely new to most practitioners in primary schools, apart from an expectation that each subject in the curriculum should be accorded a specific allocation of time in a school's planning. Subject areas and aspects to be 'covered' were more tightly defined by the introduction of programmes of study for each Key Stage, but these definitions, by and large, built upon knowledge of the best practice in large numbers of schools. The National Curriculum for Technology¹ was somewhat different. Whereas the majority of primary schools already taught aspects of all the other subjects, only a relatively small proportion had become involved in initiatives of the early- and mid-1980s to introduce design &

¹ At that time, the NC Orders for 'Technology' comprised 5 attainment targets; 4 for design and technology and 1 for information technology. Information technology was separated out from design & technology in subsequent versions of the national curriculum

technology as a regular component of children's experiences in school.² This aspect of the National Curriculum had thus, until that point, been largely in the hands of enthusiasts for the subject, rather than 'owned' by the majority of primary teachers.

The complex origins of primary design and technology predate the introduction of the National Curriculum by some years. Nationally, there had been a shift in secondary education from the traditional craft-based subjects (particularly those associated with manufacturing and the manual trades, such as wood- and metal-work) towards a more design-based approach (Penfold: 1987: 38-9). This was encouraged and accelerated by the activities of a group of teachers and researchers based at the Royal College of Art (Penfold: 1987: 41), whose vision of design education still permeates and influences thinking about these areas (particularly in secondary, tertiary and university education) today. They promoted the concept of designing as being a fundamental human capacity (Baynes: 1990a: 55), which had been seriously neglected in a schooling system based on the development of a narrow range of cognitive skills. The re-formulation of craft subjects to give greater emphasis to the design functions (as Craft, Design and Technology or CDT) later gave way to the recognition that, as manufacturing processes (the 'craft') are increasingly carried out by machines, the training of young people in craft skills is less important than their development of the more universal and transferable skills of understanding problems which can be solved by technological interventions, and of envisioning appropriate solutions. This shift to designing as the central aspect of the development of products to support and improve human life was reflected in the coining of the term 'Design & Technology' to designate this subject area.

The introduction of design & technology and information technology into the National Curriculum was seen as a priority by the government of the time, and the NC Orders for Technology were the first to be scheduled for implementation after the core subjects of English, mathematics and science. This posed a problem for very many teachers in primary schools. Primary teachers are largely drawn from among those who have been successful school students in areas associated with the humanities, the arts, and to a much lesser extent mathematics and science. Sixteen years since the issuing of that first document, it is still the case that the majority of our teaching workforce, both in primary and in secondary schools, come to the practice of education through a liberal arts and humanities background.

² Information technology was somewhat more widespread, following initiatives from the DTI in the mid-80s which had ensured that all primary schools were supplied with computers

Many teachers' own histories of school include discarding arts and the (then) crafts subjects at an early age, in the quest for what is seen as more 'academic' success. Faced with the requirement to teach a completely unfamiliar subject, many lacked adequate models of what might be involved. Opportunities for training were extremely limited (DATA: 1996 & 1998). Although some LEAs had been investing in extended training for design & technology since the early 1980s, courses of this type were available in only a small number of centres. The pressure to improve English and mathematics teaching to meet the requirements of the National Curriculum led to many schools prioritising the core subjects in their development planning, rather than the foundation subjects. Even now, only a minority of teachers in a primary school have had any but the most limited training in the teaching of design & technology.

Rationales for design & technology as a component of general primary education

As indicated above, the development of design and technology as a subject in the primary school had multiple roots. There is thus a variety of rationales for the inclusion of design & technology in the primary curriculum.

It is now widely recognised that there are different domains of thinking (Atman, 1989) – that the cognitive is not the only domain in which thinking and learning take place. Atman points out that little consistent attention has been given in previous educational thought to the conative (goal-seeking, striving) aspects of human learning. Rather it has been assumed as a function of motivation in learning. However, she demonstrates that practice and conscious attention to aspects of the conation process (very closely aligned to understandings about problem-identification and problem-solving) can increase attainment in these areas. Other writers have drawn attention to the close links between idealised versions of design process and problem-solving, or conation, 'cycles' (e.g. Chadwick: 1991, & *passim*: the 'inventors roundabout'; Williams & Jinks: 1986; Lewin: 1987, 1988, 1990; Fisher: 1989, 1991, 1998; Atman: 1989; Johnsey, 1991; Chambers & Egan: 1990; Taylor: 2000). Problem-solving and goal-directed behaviours have been identified among the key transferable skills which are required for productive participation in modern societies, and among the skills that are likely to be required for employment (Bates: 1990 & 1992; Lewin: 1990; Chambers: 1990; Kimbell et al.: 2000).

Although the idealised notion of 'the' design process has been critiqued (Baynes & Roberts: 2000; Johnsey: 1995), most writers in the field would acknowledge that design behaviours are essentially goal-oriented, and that they have specific essential

features, although the pathways between them may not be as simple as has sometimes been assumed. The development of self-directed projects of the sort that are involved in design & technology has the effect of opening the processes of goal-seeking behaviour to metacognitive scrutiny by children.

A further aspect of the relevance of practical problem-solving in learning is that it provides the learner with a memorable experience, such that concepts gained are unlikely to be summarily forgotten after the event, in line with Dale's 'cone of experience' or 'cone of learning' (Table 1).

People generally remember	
10%	of what they read
20%	of what they hear/ are told
30%	of what they see
50%	of what they see and hear
70%	of what they say and write
90%	of what they do, talk about and record

Table 1: Dale's 'cone of experience' (after Dale:1946)

There are also, as is being increasingly widely acknowledged, different forms of information processing which take place in the central nervous system. Howard Gardner, in the early 1980s, formulated a comprehensive theory of 'multiple intelligences' (Gardner: 1986) which is gaining ground among educationalists, and also gaining support from the developments in understanding of brain function which have since occurred. Initially, Gardner proposed six different intelligences. These were: visual-spatial, logico-mathematical, musical, linguistic, musical, bodily-kinaesthetic, and personal (Gardner: 1983). In later writings he separates personal intelligence into inter-personal and intra-personal components, and suggests that there may be an eighth, 'environmental' intelligence, characterised by sympathy with and interest in the natural world (Gardner: 1993 & 1998). These intelligences are not hierarchical in structure or value. It is notable that Gardner's 'intelligences' do not 'map' directly onto the curriculum 'subjects' of traditional Western European school systems. Each subject area uses different aspects of the various intelligences in different degrees. While some school subjects rely very heavily (and thus develop) only one or two of the eight intelligences which Gardner identifies, nearly all are implicated in good quality design & technology activity, with the exception of musical

intelligence, which only comes into play when specifically musical objects are being designed (Table 1). Design and Technology, then, those acts of practical problem-solving in which we all engage at some level, is a holistic and whole-brain activity, involving (and thus developing) most of the key areas of the cortex. At its best it is a subject area which has the potential to develop nearly the full range of intelligences.

Intelligence	Expression in design activity
Visual-spatial	exploring form, colour, line, shape, proportion; visual rhythm and pattern; visual aesthetics; visualising skills
Bodily-kinaesthetic	exploring materials; developing craft skills; exploring form and texture
Logical-mathematical	estimating; measuring; calculating (e.g. proportion); planning sequences of actions
Interpersonal	identifying and analysing the needs and wants of end-users; negotiating in teams; setting goals and work plans; evaluating outcomes
Intrapersonal	Setting goals; exploring preferences; evaluating outcomes; metacognitive understanding
Naturalistic / environmental	sourcing materials; considering whole product life
Linguistic	explaining ideas; negotiating with partners or teams; learning technical vocabulary
Musical	When designing musical instruments, acoustic environments etc.

Table 2: The relationship between Gardner’s intelligences and practical project activities (Design & Technology)

Knowledges have also been identified as being of different types. Ryle (1949) discusses the differences between ‘knowing about’, ‘knowing that’ and ‘knowing how’ (Ryle: 1949; Eggleston:1992). Design and technology has a particularly important role to play in developing children’s capability and self-confidence in capability – the importance of ‘knowing how’. It thus can be seen as a subject area which is empowering to the individual in a society increasingly reliant on complex and interacting technologies.

Connected with the above, is an increasing concern with the development of visual understanding. Writers such as Roberts, Archer and Baynes (1992) identify the development and practice of visual thinking skills as one of the major rationales for design as part of general education.

Similarly, because design and technology is taught through a project approach, it provides clear opportunities for the teacher to 'scaffold' (Bruner, 1966) and facilitate constructive learning. Forman (1996) suggests that the sort of project in which children are encouraged to express their understandings in a variety of ways (as in the Reggio Emilia schools) offers teacher and learner an ideal forum for the social construction of knowledge, and for constructivist teaching and learning.

Another increasing concern in educational, governmental and industrial circles is that knowledge-driven curricula restrict the opportunities of young people to practise and develop creative skills and attitudes. Creativity is essentially to do with making links between knowledges, enabling information to be processed and reprocessed in different ways (Koestler: 1964; Sternberg: 1986; National Advisory Committee on Creative and Cultural Education: 1999). Implicated in the development of creative abilities are a number of factors. The ability to visualise (think visually) appears to be well-developed in all creative individuals, in whatever field of endeavour they operate (Sternberg: 1986). Creativity is also connected with 'divergent intelligence', or 'lateral thinking' (de Bono: 1972 & *passim*) – the ability/tendency to seek novel solutions to problems, rather than to rely on previously-learned solutions. Again, it can be claimed that design & technology offers opportunities for children to exercise both visual thinking and lateral thinking skills.

Egan points out that

Vygotsky [...] argued that we make sense of the world by use of mediating intellectual tools that in turn profoundly influence the kind of sense we make. Our intellectual development, then, [...] requires an understanding of the role played by the intellectual tools available in the society into which a person grows [...] Intellectual tools [...] are gradually internalized as the child grows; [...] . So the set of sign systems one internalizes from interactions with particular cultural groups, particular communities, will significantly inform the kind of understanding of the world that we can reconstruct (Egan: 1997 : 29).

An issue for educators and others in so-called 'knowledge economies' is that some of the intellectual tools that could be available to the community are selectively lost when the focus of education becomes narrowed. Thus, if 'the set of sign systems one internalizes from interactions with particular cultural groups, particular communities [...] significantly inform the kind of

understanding of the world that one can construct' (Egan: 1997 : 29), then a diminution of the range of intellectual tools results in certain sorts of thinking being lost from the community at large. With an increasing pace of technological change, fewer and fewer members of the community believe themselves to have access to the basic understandings that allow them to feel in control of technologies. They are more likely to feel controlled by the technologies on which they depend. The key purpose of design and technology education is not to maintain a supply of technologists, but to build a community of people who can make educated choices about the technologies that they want and use, who feel empowered rather than disempowered by technologies.

'... the mind is not an isolable thing like the brain inside its skull; it extends into and is constituted of its sociocultural surroundings, and its kinds of understanding are products of the intellectual tools forged and used in those surroundings' (Egan: 1997 : 29). I would argue that technological understanding, 'knowing how' as well as 'knowing about', is a key intellectual tool of which we should not lose sight. Moreover, by engaging eye, hand and brain in the development of artefacts and products, technological learning affords an important arena in which the Somatic and the Ironic can interact: 'Somatic understanding provides to Ironic understanding something beyond language, something foundational to all later understanding' (Egan: 1997 : 169).

Recurrent initiatives focused on promoting more strongly the linguistic and mathematical attainment of children have drawn the attention of educators away from the key role of practical work in fostering children's understanding of a range of key concept areas – including those of literacy and mathematics. One effect of this is a reduction in the proportion of intending teachers who choose the practical subjects as specialist areas. An increase in the amount of time devoted in teacher education programmes to the development of children's skills in literacy and numeracy has been at the expense of time devoted to a wider, and potentially more engaging, curriculum. It has thus become important to consider ways in which the intending teacher can be given sufficient grounding in subject areas other than those in the 'Core'.

In the main teacher education programme in my institution, the strategy adopted has been to offer optional modules that allow students in the later stages of their development to select one from a small suite of subject modules. Currently this is embedded in the penultimate year of the programme, and in the new programme that is superseding it, there will also be optional modules offered in the final year.

Students are debarred from choosing either their own specialist subject, or any that they have pursued in post-16 education. Design & Technology has been a popular choice.

Process

The central dilemma in teaching these undergraduates is that they are typical of teacher education students– their areas of greatest experience and expertise tend to be in the humanities and liberal arts. They tend to lack much of a background in the practical. At the outset of the module, they are asked to write a short reflective piece about their own perception of their learning. They are given a ‘writing frame’ with a starting point, and invited to complete it in as many ways as are important to them. The starting point invites students to reflect upon times when learning has been successful for them personally. They are asked to complete the sentence: ‘I learn best when....’ . Material from the exercise was analysed using a grounded theory approach (Glaser & Strauss: 1967; Strauss & Corbin: 1998).

In the following table, the main clusters from this exercise from two groups of non-specialists are compared with those derived from the identical exercise undertaken by a group of trainee teachers specialising in design and technology, and taking a very similar module. A number of students also identified additional features of the learning environment or experience as personally important; this tail of personal statements which do not form any clear clusters has been omitted from the table.

From this it can be seen that the key areas which are identified as important are the same for both specialist and non-specialist students. It is perhaps surprising that the importance of practical and visual work is emphasised more by the non-specialists – possibly because students with a strong background in practical problem-solving take this aspect for granted. Personal ownership of the project, and commitment to shared working with a team appear to be more important to the specialists – perhaps because in previous modules on their specialist course they have had more experience of team projects. Personal interest, ownership, and freedom to work to a sequence of the individual’s own choosing are important to both groups.

	generalist		specialist	
	n=37		n=19	
		(%)		(%)
working with others	5	(14)	8	(42)
work in groups to share ideas and learn together	5		8	
personal interest/ ownership	12	(32)	14	(74)
I am interested in the topic	8		10	
ownership	1			
can voice my own opinion	1			
I can work at my own pace	1		3	
can work in stages	1		1	
practical/ visual focus	37	(100)	12	(63)
practical task/ hands-on approach/ practical participation to see how things work	27		9	
I can see what I am learning about/ visual aid	10		2	
it's not all from a text book			1	
supported independence	8	(22)	2	(11)
teacher models task	2			
shown how to do something and left to tackle it alone	3			
I have support	1			
there is interaction with the teacher	2		2	

Table 3: Key aspects of importance in undergraduate teachers' learning experiences – a metacognitive exercise³

There is some emphasis on heuristic learning – being given support for working things out on one's own - and the value of 'trial and error' learning.

The task that was set for the students was to develop a table-top toy that would stimulate children's interest in mechanical systems. This was then to be taken into a school and evaluated by using it with a group of children of the target age range. How the toy was to be designed and constructed, and how the student would then plan the work with the children was left open to their own ideas. The students investigated a range of automata, and modelled a variety of mechanisms using construction kits such as Lego™. A key feature of the module was the release of teaching time to allow students to seek individual workshop help in the construction of their final piece, and to spend time in school.

³ Percentage figures have been rounded to nearest whole number

Alongside developing their personal work, the module used a range of practical activities as a vehicle to explore some key issues about the teaching of Design & technology in schools – planning for progression, the inclusion of children with a range of learning and physical difficulties, the management of project-based work, and the use of modern technologies in supporting design work.

All students successfully completed the task of developing a toy, and their evaluations of the outcomes show a high degree of personal pride in achievement:

I am very pleased with my toy as I feel that it fulfils all of my aims, which were that it is robust enough for the children to handle, made from durable materials and that it is visually pleasing

I am really pleased with my final product. [...] the toy is actually much better than what I had expected [...] I was worried that I would not be able to make a toy of a high quality that would also be of interest to children. However, I feel that I have met the features necessary in the specification given and I am very pleased with the outcome.

I never imagined my toy would work quite as well as it turned out.

I am overall very pleased with my mechanical toy and the end result

They also found the work with children in school more beneficial than they had expected:

Taking my toy into school I found extremely helpful as the children responded so well to my activities

Throughout the exercise I noticed how effective having a toy that demonstrated the aspect was being learnt made a remarkable difference to the child's learning

Overall the children seemed to really enjoy our [...] design and technology session.

They remained interested throughout the whole period, and although the level of response varied [...] I feel confident that they all went away with some new knowledge and having benefited from the experience.

Most students also reflected on aspects of their learning through the assignment:

On reflecting on my learning through the designing and making process, I have had a lot to consider and overcome for it to be a successful table-top toy. I have learnt a lot about the construction of wood, the various tools you can use and how to use them appropriately. [...]. I also learnt that through the designing process it is all right to change and modify ideas in order to make the toy more appropriate to the intentions [...] I learnt you need to take time and care

This process has allowed me to recognise the importance of careful planning in design and technology

I have learnt a vast amount about mechanisms. [...] I found I learnt most whilst actually constructing the toy. Once I had made the mechanisms and could see how they would work I was able to develop my ideas. The construction process involved a lot of trial and error as I was learning as I went.

To reach this point has taken a lot of time and effort. I have realised how much thought, planning and designing is needed before going ahead and constructing a mechanical system

At the end of a module, all students are asked to complete an evaluation form focusing on their overall learning and the quality of their experience. The student evaluations clearly indicate that they recognise the progress that they have made:

I feel I have met all the targets expected

They emphasise the development of subject knowledge through this open-ended approach which has allowed them space for growth:

I have particularly improved my subject knowledge
Making the toy has developed my knowledge and skills a lot
Felt I learnt a lot about use of ICT in DT
Good use of learning on different mechanisms
Have become familiar with units of work
Pleased with my progress on the mechanical toy

They relate their developed understanding to an increased level of confidence in working in this way with children:

Good module thank you I feel more confident when it comes to teaching DT
Making the toy and portfolio has not only been enjoyable but increased my knowledge and understanding and confidence for teaching DT
Looking forward to putting this into practice
Have learnt some strategies for when in school teaching
Have a had a valuable set of lessons and acquired lots of ideas to do with children in DT

They emphasise their enjoyment of the module, relating this to the practical nature of the learning

I enjoyed the hands-on approach to the module and the practical tasks we were able to use to enhance the learning. I like the assignment and have enjoyed progressing in this
I have really enjoyed this module especially the practical aspects and tasks used to demonstrate the sessions' focus
I thoroughly enjoyed the module
Enjoyed the practical tasks and the chance to try out new programmes

Conclusion

A number of factors combine in making this a successful learning experience for the students. The combination of practical action and deep reflection, involved in thinking out their ideas for construction, modifying these in the light of experience, and considering the match between intentions and outcomes puts the experience high on the scale of the 'cone of experience' (Dale: 1946) and successfully combines the Somatic and Ironic modes (Egan: 1997). The value of a learning experience in which a set of intended learning outcomes are combined with recognition of the learners' needs of space for growth is reinforced here. The interplay of different intelligences (Gardner: 1983, 1991, 1998) in contributing to the final outcome (in terms of learning as well as in terms of the 'product' made by the students) also renders the learning very powerful.

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