BEYOND DESIGN: A NEW PARADIGM FOR TECHNOLOGY EDUCATION

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Abstract

The concept of a design as an underlying structure for technology education process is well established and a number of models of increasing complexity have been produced to explicate the process. Allied to this has been a strong design-make-appraise approach to many emerging technology education curriculum statements, and this concept appears to underpin much of the practice in New Zealand classrooms. The evidence strongly suggests that this model reflects neither the way designers work in the adult world, nor how children work in the classroom. This paper begins by examining the development and implementation of models of design processes and the influence of these on teacher's classroom practice. The actuality of the practice of professional designers and student designers is then explored. The paper then argues that if technology education is to flourish we need to reject reference to design process and develop a new paradigm which reflects more accurately technological practice. Finally it offers some suggestions as to what a new paradigm might be, and briefly outlines an on-going Action Research project investigating the application of the approach in the classroom.

Background

The move to introduce technology education as a compulsory element in education systems has gained increasing momentum since the 1980's, and the process of curriculum development has been well documented . A very influential model in this process has been the Design and Technology Curriculum introduced in England and Wales in 1990 . Later revisions of this Technology Curriculum in 1995 (Department of Education, 1995; School Curriculum and Assessment Authority, 1995) and 1999 narrowed the focus onto designing and making based on a clearly structured progression of skill development and technological activities. The approach to technology advocated by the Australian Education Council, which has served as the model for a number of Australian States shows an influence of this trend. Although Designing, Making and Appraising is only one of four strands, much of the literature emanating from Australia tends to view Technology as congruent with a design-make-appraise process. In the United States the proposal of the International Technology Education Association postulates technology as defining problems – ideas- model – test. The New Zealand Technology Curriculum statement reflects the wider, more socially oriented approach of the 1990 English/Welsh curriculum but research (and anecdotal evidence gained from discussions over the last five years at Auckland College of Education with lecturers, advisors, and students returning from practicum (Mawson, 2001) would seem to suggest that a design-make appraise construct of technology is strong within all sectors of the New Zealand school system. A similar situation has also been evident in Canada .

The Design Process

There exists within the literature of technology education some confusion about the nature of the relationship between technological practice, the design process and problem solving. Johnsey sees the design process which he defines as "the complete action from when a design and make context is explored through to making and evaluating a product which satisfies an identified need" as being the same as technological practice. On the other hand Eggleston believes the design process is the process of problem solving which begins with a preliminary idea and proceeds until an optimum answer is attained. The design process above all else is of logical rational analysis. Williams identifies a number of processes which students may use as part of their technological practice, two of which are design and problem solving. He believes that despite the fact that the terms design process and problem solving are often used interchangeably, problem solving is different from design in that design deals with ill defined problems, and may not begin with a problem, while of course problem solving does. Whatever view of this relationship is held, the published models of the design process, the technology process, and the problem solving process have been very similar both in the terminology and the sequences of activities identified.

The attempt to define the design process on which technology education should be based now has a reasonably long history*.* As naturally occurs with paradigms over time (Kuhn, 1965), an increasing number of anomalies to the initial model of the design process have emerged, and attempts to adapt the model to encompass them have been common. Although there are many models, all describe a common thread from the inception of an idea to reflection stage to evaluate the success of the outcome . Johnsey (1995) identified seventeen different attempts at defining the design/problem solving process in England between 1971 and 1995. He found a surprising consensus of opinion as to the nature of the design process. While these models moved from a very linear to a very complex iterative pattern during this time period, the basic elements were essentially the same. He identifies fourteen common process skills which tended to be seen as a linear progression. Indeed a common element identified in the English literature is the adherence of teachers of technology to a linear concept of the design process, despite increasing rejection among researchers of even iterative models of the design process . Linear models still continue to be promulgated. The recent Graphics Education Year 9-13 Guidelines in New Zealand which reinforces the fundamental relationship of graphics and design to technology provides a linear model of a design process "which can be adapted to every design brief" (p.16). The concept of the design process is now well established as a dominant discursive regime in technology education (Foucault, 1980)

A number of reasons have been advanced to explain the emergence of these models of the design process. It has been suggested that the principle motive for the development of models of the design process was to make possible the teaching and assessing of technology education in order to impose order on what is an essentially confused interactive process . The unique nature of technology education as a new curriculum area posed a wide range of problems for most teachers. Roberts and Norman believe that the models which were employed in the early 1970's to introduce teachers to the meaning of design and technology, became so simplified that a lowest common denominator was reached which became accepted as the design process. They also see the acceptance of this process as solving the problem schools faced with management, assessment, and resourcing if students were allowed to indulge in open-ended problem solving (. With the regard to the technological process many teachers particularly in primary schools had no clear model of how designing works (Anning, 1992; Jones & Carr, 1993, . It would seem that in order to teach designing effectively teachers need to have a personal, even if rudimentary understanding of how the design process works. Models do serve to provide that elementary structure but all tend to encourage teachers to structure designing activities as a sequential rather than an iterative process . In England the Assessment of Performance Unit was quick to point out the dangers of this to the development of technology education. They acknowledged that the models had been a helpful guide but observed that they had been equally dangerous in prescribing "stages" that need to be "done" by pupils which had the effect of turning the process of design and technology into a series of products .

Also referring to the situation in England, Johnsey raised similar concerns. He saw the structure of a single simplified process imposed on what was an unfamiliar and process oriented subject as initially being of help to the non specialist primary teachers, in that it provide a sense of security and some guidance how to proceed. In the longer term however, as teacher's perceptions and expertise improved he felt that there were dangers in representing pupils design activities in such a simplistic way. Chidgey had also clearly signalled the negative effect on technology education of adherence to a design process model .

A similar pattern emerged in Ontario as teachers put a new curriculum into practice Although design in real world is creative dynamic, iterative, in schools technology tended to become Design-Make-Appraise cycles based on a closed design briefs, which were teacher assigned and unrelated to students world . Like Kimbell and Johnsey in England, Hill also believes that as the design process is not a neat systematic process but instead has iterative patterns, and has to produce some order from disorder, it is questionable to present it to students as a linear, simple process. It is highly likely that the use of such models to help develop understanding of the technological process in pre-service education and in-service professional development has had a similar impact on the classroom practice in New Zealand.

There would seem to be a more fundamental problem with the use of models of the design process in technology other than the distorting of an iterative process in a linear direction.

Models describe what is hoped will be the behaviour of the pupil designer by emulating the process we believe is used by the professional designer . Despite efforts to refine and improve models of the design process the evidence seems very clear that the fundamental belief behind the concept is at odds with the reality of the way in which professional designers and student designers actually work. Designing doesn't and probably never has taken place in a linear manner and it is not realistic to portray complex processes in a simple diagram, as no matter how refined it becomes it can never be a complete description of designing . If this is the case, then further efforts to explicate the process and produce "The Model" which we can "teach" students and which will serve in all circumstances not only appear futile, but may also serve to hamstring the development of true technology in classrooms around the world . In the view of Roberts and Norman (1999), in the design and technology area research and curriculum development are hampered by myth and ideology masquerading as established facts. They see the doctrine of the "design process" as a transferable skill as an example of this. Similarly, the contextualised nature of problem solving and the problematic of generic, transportable problem solving processes has been well documented by McCormick and his fellow researchers [e.g. .

Conflicts between Theory and Practice

There has been very little research about design and therefore very little informed guidance how to teach it. There seems to be no generalised process and none of the models appear to be based on direct systematic observation. While the idea is that there is a systematic process which can be taught and learned by all pupils who can then apply it to subsequent problems and situations the little research there is indicates it does not work this way, either in real life or in the classroom (Roberts & Norman, 1999; Williams, 2000; . Neither students nor designers naturally utilise a predetermined process in their work, instead they invent a process as they proceed towards task completion. The outcome of a design, or the solution to a problem, involves more variables than can be represented in a sequence of process steps . It has been suggested that the whole concept of design espoused in the school system may be an artificial construct, with tenuous and problematic links to reality . Designers deal with very ill defined problems, and the complexity of the working process is such that it cannot be reduced to a simplistic model . Indeed how designers deploy the knowledge, skills, and values which facilitate their designing, may be indescribable in linguistic terms and therefore not susceptible to modelling.

The way the model has been interpreted by teachers has also been criticised as flying in the face of student working methods and capabilities. Inherent in the design-make-appraise model is the idea of the student developing a final design, normally as an annotated drawing, before the making process begins. Although a number of possible options may have been identified and graphically explored, the key element of the process is the selection and design of the final solution. In this approach, the making process merely seeks to produce the outcome encapsulated in the design, and the appraisal centres on the quality and appropriateness of the produced outcome.

There are a number of points raised by the critics of the emphasis on drawing designs at the beginning of a design, make, and appraise technological unit. Kimbell, Stables and Green, 1996, believe "It is one of the commonest and most serious misconceptions in Design and Technology that design development can only happen on paper with a pencil" (p.97). The belief that young children can use drawing as a means of modelling and developing ideas which was strongly held in the late 1980’s has been challenged and it has been suggested that this may represent an inappropriate paradigm of secondary technology being transferred to the primary sector . There are a number of studies which show there is a weak link between design and making, and that children don’t refer to their drawings when modelling (Rogers & Wallace, 2000; Welch, Barlex & Lim, 2000; Anning, 1997a; Anning, 1993).

Other researchers have pointed out that pupil behaviour is not the same as that described by the models. Johnsey (1998) for example believes that for pupils making is the important part, which begins early before the designing activities are complete, and continues with same frequency and intensity until the solution is reached. Many of the accepted designing skills are displayed for only limited periods (and sometimes not at all) and not solely at the beginning of the task . When faced with the requirement to follow a prescribed, linear model students tend to subvert the design process by adopting their own strategies to get the job done, but ritualistically use the teachers approach to satisfy assessment designs .

Students’ Technological Practice

If the critics are correct is asserting that models of the design process do not, and cannot, reflect the technological practice of students in classrooms then what forms does actual practice take? Although the wider body of research focuses more on factors influencing and limiting student competence in technology, providing some clear signposts for the teaching of technology education in the process, enough research on student technological practice has emerged to allow some patterns of behaviour to be identified.

Some evidence exists as to the range of strategies children use to begin a technological task, and of the problem solving strategies they employ as they move through the process.

Strategic knowledge (how to decide what to do and when) seems particularly prominent during moments when children are sorting out a way forward and decisions made during these first moments of considering a task can set children along different paths for solving the technological problems . Gustafson and Rowell identify five types of initial problem solving strategies: (i) guidance/direction (ii) modelling handling, (iii) imaging (iv) social beginning and lastly (v) reflecting beginning. Children’s selection of an initial course of action were very much influenced by the children's perception of where ideas to solve the problem might lie.

Roden looking at the problem solving strategies of children in their first three years of school, developed a taxonomy which identified eleven different strategies, the relative importance of which varied over time, and each of which gives rise to a particular pathway through the design process.

Both of these pieces of research therefore show a wide range of student technological practice which do not reflect design process models, and which would not be able to be adopted in classrooms where delivery was based on a model. Other research findings also indicate technological practices of students which do not fit the models (Jones & Carr, 1993).

Although the models of the design process place a strong emphasis on the role of two-dimensional drawing in creating the original design, the research indicates this is not the preferred method for children. . When allowed to choose their own pathway they design orally or in three dimensions, or begin by exploring the materials and tools available to them. .

There are also a number of other technological practices of children which are at odds with the models of the design process. Children develop solutions serially, rather than developing several possible solutions at the outset before choosing one to pursue . Nor do they follow a sequential pattern of activity within the process. Children move from one type of design activity to another fairly rapidly, and making and designing occur concurrently . In New Zealand detailed examination of the technological practice of 261 children aged six to fifteen years revealed a wide diversity of practice within the same class, and little evidence of children proceeding in a linear fashion through all the steps of the process .

If the present models of the design process do not, and, because of fundamental flaws in the concept, can not represent the reality of children's technological practice in the classroom, is there an alternative view which may offer guidance and direction for teachers?

The most widespread investigation of the technological practice of students is that of the Assessment of Performance Unit in England which provided 20,000 pieces of work, two from each of 10,000 students . Their analysis of this evidence led them to reject current models of the design process and postulate instead an iterative interaction of the internal (mind's eye) images and their expression in drawings and models (p. 24). Although it is now ten years since this model was originally published, it appears to have had little impact on classroom practice. The concept underlying the APU models does seem to offer some foundation for a new pedagogy in technology education. The need for both capability/skill and knowledge/reflective aspects in technology is well documented and gives clear weighting and importance to both aspects. It also focuses attention on design skills which are crucial for technological practice, and which are seriously neglected in current practice. In England there is evidence children's skill in designing lags behind making because students are either not introduced to a sufficiently wide range of design strategies or are not taught to use them effectively , and a similar state of affairs exists in New Zealand.

For students to move successfully through a technological process to achieve an appropriate outcome they need both design skills which allow them to successfully model their developing concepts and information literacy skills which will allow them to locate, access, process, reframe and present information.

Teaching Practices

Much current classroom teaching practice would seem to be limiting children's technological practice. Teachers in general do no place much importance on drawing in their classroom programmes, and seldom model different drawing methods (Anning, 1997a; . As a result children lack understanding of purpose of design, and lack drawing skills . The ability of young children to draw in a technologically appropriate manner is often underestimated .

As is the case with 2D sketching, little specific teaching of 3D modelling occurs at present. The purposes of modelling are rarely made explicit to children. Choosing the most important form of modelling involves thinking not only about what the idea is that needs to be expressed but also equally about how the modelling is supposed to help . Seldom do teachers indulge in "ways of talking" that help children to be aware of their ability "to see in their minds eye" and to make use of sketch models for developing .

Another area where students design skills are lacking is in their understanding of the nature and properties of materials. Although children by preference begin by gathering and handling materials, which allows them to explore design possibilities and strengthen mental images, this opportunity to play and experiment is seldom given them. Children are often asked to design without knowledge of available materials and their properties . As a result their designs may often exceed their technical skills of children or the limitations of the materials available to them .

It has been suggested that often we ask the impossible of young and inexperienced designers, in that we want a quality crafted product and also for them to find creative and innovative solutions to design problems . In New Zealand, not only do we not teach and give time to practice fundamental design process skills, because of the curriculum emphasis on technological areas we often expect children to design in a vacuum.

Teaching Strategies to enhance learning in Technology

Other research findings also offer insights into how teaching strategies may enhance student learning in technology. One aspect of this is the importance of focussing on the context and way in which the technological task is defined. The context and the way the activity is introduced whether certain behaviours are exhibited by students [Johnsey, 1998; Kimbell, 1994). The problem context can include the subject matter of the task, the degree of structure present in the task setting and the opportunity for iteration between action and reflection. The effect of the nature and structure of the task on gender and ability levels has been clearly documented . Young children often find real life contexts in technology much easier to operate in than teacher defined, abstract situations. The way in which the task is introduced can also be used to enhance the technological practice of young children. There is some evidence that where the activity is clearly structured and modelled children can use designs for making . Simply beginning may act to simplify planning inasmuch as it may reduce the number of alternative courses of action. Younger children therefore may find this planning strategy makes the problem solving potentially manageable in that it allows them to get on with the task leaving remaining decisions to be improvised as ideas emerge from handling materials .

If the current teaching of technology education in New Zealand is similar to that in England, Ontario and Australia with a reliance on an inappropriate design process paradigm, an unbalanced focus on product outcomes, and a reluctance to teach the design skills students require to achieve success in technology, then it is time for a new pedagogical approach.

The understandings that can be gained from the research discussed above do offer the framework for a different pedagogy which may be more productive in achieving the development of technological literacy which is the fundamental aim of the New Zealand Technology Curriculum Statement .

Towards an new paradigm

Under such a new paradigm, a unit of technology education might follow this pattern. The children would be given time before the need/opportunity/problem was posed to immerse themselves in the context of the task. During this exploration of the general knowledge, relevant information, and social attitudes relating to the particular context, children would also be given an opportunity to explore the range of materials available to them when working towards their solution. If appropriate some whole class teaching of design skills such as drawing or technical skills may take place, particularly if these are seen as crucial to a successful outcome for the intended study.

The scenario that was used to introduce the study to children would be seen by the children as authentic and relevant to their experience and environment. The task itself would be sufficiently open to provide the possibility of a range of solutions being developed and the children would be encouraged to choose a starting mode which fitted their preferred learning styles. Designing and making would occur concurrently and at regular intervals children would be required to explain/show, and discuss their developing solutions with other students and the teacher. The children would be either working by themselves or in socially constructed units, depending on the task and their own inclinations. The final outcomes would be presented in a range of presentation modes.

The role of the teacher

The role of the teacher during the unit would be to model technological practice and manage the learning environment. S/he would act as a catalyst by providing helpful, critical but supportive comments of pupils work. As collaborative technological problem solving requires close attention to the development of language skills as well as the use of tools and equipment, the teacher would be modelling strategies such as clearly identifying the problem, challenging, counter challenging and explaining. This is all the more important because of the inability and reluctance of students to display their ideas in diagrams and sketches . As well as modelling these language skills, teachers would also need to consistently model information literacy skills, as these are basic to children’s ability to gain the technological knowledge and understanding (Strand A) and the awareness of the relationships between society and the technology they are working in (Strand C) to complement the technological capability they were developing. The teacher would also be monitoring closely group dynamics to ensure group task differentiation was not resulting in independent and not collaborative work. In such cases s/he would need to offer support for the establishment of "zones of contact" to create interaction .

Such a mode of teaching would begin to develop the type of students which are envisaged in the Technology Curriculum Statement . That is, students who are independent problem solvers, are innovators and risk takers, who work collaboratively and are creative and reflective, and who are becoming critical consumers of technology. There is little evidence that such characteristics are developing in the present environment which is dominated by inappropriate models of the design process and emphasis on the production of a product.

Trialling the model – an Action Research approach

The teaching and learning approaches outlined above are being used as the basis for a series of Action Research projects with two classes of New Entrant/Year One children (age 5/6) and three classes of Year Seven and Eight children (age 11-13) in two Auckland inner city schools. The first project with a new entrant/year one class has been completed and a commercially produced video of the process is due to be completed in December 2001. A similar class in the same school was used as a control group and it completed the same unit using the accepted design process model approach. Although data analysis is still in a preliminary stage initial some clear differences in involvement, conceptual knowledge and quality of outcome are emerging. The experience and knowledge gained in this first project will be used in the initial planning cycle for the next project with a year seven and eight class in March/April 2002.

Conclusion

This paper has argued that the focus on models of the design process have been based on a fundamental misunderstanding of how professional and novice designers actually work, and has been driven by management and assessment needs. The result has been to distort and limit the development of technology education in New Zealand classrooms. It has suggested that reference to models should be dropped and that attention be given to providing children with the necessary design skills and information literacy skills to enable them to move comfortably and successful between mind's eye and hands on development of technological solutions. Finally, a possible teaching and learning scenario has been outlined which would allow such a change to occur.

REFERENCES