

# Educational Research and Curriculum Development: The Case for Synergy

## Abstract

Educational research has been criticised for being inaccessible to practicing teachers and both removed from and irrelevant to their needs. Seldom does the research inform curriculum development, the production of learning materials, or their effective use in the classroom. This paper describes how materials developed by the Nuffield Curriculum projects for design and technology have made use of research findings from both large-scale and small-scale research studies. The paper continues with a description of how the results of this research informed by curriculum development can in turn inform subsequent research such that a synergy is established that is beneficial to both endeavours.

The paper concludes with the results of a trial in which 20 teacher candidates from Queen's University in Ontario were:

- a) introduced to the Nuffield approach to teaching design and technology
- b) participated in the development of a capability task and supporting resource tasks
- c) were engaged in using research findings to inform curriculum materials development and implementation.

## Introduction

Educational research has been criticised for being both removed from and irrelevant to the needs of practicing teachers (Hargreaves, 1996). Hargreaves (1996) has identified the gap between educational researchers and practitioners as a 'fatal flaw' (quoted in Tooley and Darby, 1998: 7). It is frequently the case that educational research does not investigate the concerns of teachers, and when it does is often published in a form that is unlikely to be easily accessible to them. Even less frequently does the research inform curriculum development, the production of learning materials, or their effective use in classrooms. This was certainly true in the field of design and technology education, where only recently has a significant body of empirical research become available to curriculum developers.

Much of the work in any curriculum development project is, of necessity, guided by the project director's intuition, a 'seat of the pants' response to limited piloting and anecdotal evidence from enthusiastic teachers. This paper does not deny the importance of such influences, but argues that other factors can, and do, inform curriculum development. Taking the Nuffield Design and Technology Projects as its main example, this paper traces

the influence of a variety of research findings on the approach to teaching and learning adopted by the Projects and the materials they have produced. This paper then illustrates how the results of research informed by curriculum development can then inform subsequent research such that a synergy is established which is beneficial to both endeavours.

## Introducing a new curriculum: top down or bottom up?

The introduction of the National Curriculum into England and Wales in 1990 is a working example of what Bennis, Benne and Chin (1969) called the 'power-coercive strategy'. The new curriculum became a statutory obligation, requiring all state schools to teach design and technology, a new subject, irrespective of teachers' preparedness, relevant skills and experience, or professional opinions. The new National Curriculum can also be described in terms of Schon's (1971) 'centre-periphery' model of change, the success of which requires that an innovation be fully developed and detailed prior to diffusion. This was clearly not entirely true for the design and technology component of the National Curriculum. The lack of published materials may be seen as a serious impediment to curriculum development, as the perceived wisdom is that such materials should be available to support teachers who are sympathetic to the changes required by the new curriculum. MacDonald and Walker (1976) describe this approach as typical of the Schools Council and Nuffield curriculum projects:

*'The attempt to change the curriculum by publication of materials which have been written to embody particular ideas and values is a common one. 'Materials production' forms a basic activity for most Schools Council and Nuffield curriculum projects.'* (p. 102)

The development of food technology in primary schools as part of design and technology provides an interesting example of the growth of classroom activity in response to a centre to periphery initiative in which there was a dearth of printed resource materials and development. Although slow to begin with, development did take place through the work of dedicated individuals responding to statutory requirements (Eaton, 1993; Jewiss and Hopper, 1992). It is clear that such work needs to be disseminated if it is to inform practice on a wide scale. It is here that the work of curriculum development projects such as Focus on Food (Cormac, 1998) and Primary Nuffield Design and Technology (Barlex, 1998) can provide the means for circulation of grass roots thinking

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in forms that are accessible to busy teachers. The view of the Nuffield Primary Design and Technology Project is that this 'follow up' to statutory requirements based on emerging good practice in response to those requirements is both a sensible and an effective approach. The approach is sensible because such practice is developed by those with energy, vision, competence, and considerable classroom experience. Hence it is likely to be good practice and transferable to other teachers. Equally, the approach is effective because research, conducted by independent evaluators on the way teachers use the trial printed resources developed by the Nuffield Primary Design and Technology Project, indicated that the materials would be of considerable benefit to experienced teachers as well as those new to teaching design and technology (Murphy and Davidson, 1998). Those new to teaching design and technology taught with the materials very much 'as instructed', saving any adaptations until 'next time round'. The Nuffield Project has anecdotal evidence that changes were made in subsequent use of the materials (Messenger, 1999). Experienced, confident teachers were able to adapt the teaching suggestions according to their perceptions of the needs of the children being taught. In both cases the teaching and learning were deemed effective by the evaluators. This is very much in keeping with the view of Bloomer (1997):

'Teachers are not merely points in some conduit linking centralised prescriptions to learners' desks. They are not technicians, faithfully acting out the detail of prescribed blueprints. Rather, they 'act upon' prescriptions in order to create learning opportunities.' (p. 137)

#### **The influence of the assessment of performance in design and technology on secondary Nuffield design and technology**

From its inception in 1990 the Nuffield Design and Technology Project committed itself to listening to a wide range of influences that were operating on the embryonic design and technology curriculum: existing practice, the aspirations of the subject, the statutory requirements, emerging practice, inspection reports and research findings.

At this time (1985-1991) the Assessment of Performance Unit (APU) for design and technology, under the directorship of Professor Richard Kimbell at Goldsmiths' College in London, was developing sophisticated pencil and paper tests to probe students' capability in many facets of design and technology (Kimbell *et al.*, 1991). This

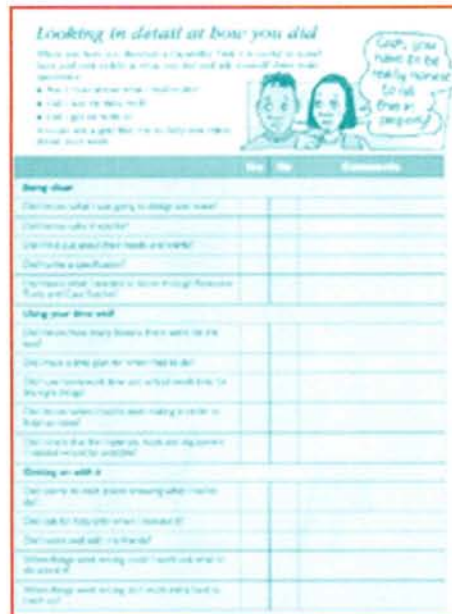
was occurring at a time when design and technology did not exist as a subject in the school curriculum. Kimbell's team argued the case for design and technology capability as an educational reality that was recognisable and could be assessed. The data they collected through assessing over 15,000 students aged 15 years enabled the team to make a wide range of findings, including:

- balanced capability in design and technology requires students to be reflective and take action in equal measure. Some students exhibit unbalanced reflective-active profiles.
- integrated capability in design and technology requires a high level of appraisal within the reflection and taking action
- students from different subjects exhibited different strengths within their design and technology capability. For example, students from home economics showed particular ability in identifying issues that underpin the test task, while students from craft, design and technology (CDT) showed particular ability at being active in response to the test task.
- students of lower ability performed better in the more structured tests.

The Nuffield Design and Technology Project was aware of these findings and used them in a number of ways. It acknowledged the active-reflective balance required for students to become capable. The Project had collected considerable anecdotal evidence from teachers about the effect of this in the classroom. Typical was the comment about some boys: 'If only he'd just stop and think before he rushed in and did it.' A typical comment about some girls: 'If only she'd do something rather than just sit there thinking about it.' The Project developed materials to encourage students to consider their active-reflective balance. The student can use these at the end of a Capability Task to review performance and to set targets for improvement in the next Capability Task. For example, 'Understanding what keeps you back!' (Figure 1) is the simplest and can be used with a wide range of ability. It is important that this worksheet is completed quickly; 10 minutes maximum. It provides a useful opportunity for students to discuss any difficulties under three headings:

- **Stop/Go** What held me up? and How did I overcome it?
- **Help** When did I need it? and How did I get it?





- The Project had considerable sympathy with the need to engage students with the continual appraisal of their developing design ideas. It discussed this at length in the teacher guidance materials it produced (Barlex, 1995a) and introduced students to the idea of formally reviewing their progress at key points in making design decisions. Underpinning this idea of formally reviewing their work at key points was the idea that students should be continually reviewing their



Figure 4: When do you review?



work as it progresses. The formal review provides the student with a chance to take stock in consultation with the teacher. Two examples from the Nuffield Study Guide for students are shown below (Figures 3 and 4).

The APU finding that different subjects led to students showing different strengths in turn led the Nuffield Project to realise that it was important to use these strengths in a way that would make them available to all teachers and all students working in this newly established subject. This led the Project to hold a series of seminars with teachers from different disciplines to identify the contributions they could make from their particular subject background. The results were extremely useful in establishing a collection of strategies useful for generating, developing and communicating design ideas; strategies that could be used to make design decisions (Figure 5).

Figure 5: Strategies useful in design and technology.

### Strategy

#### Identifying needs and likes

- Observing people
- Interviewing
- Looking in books and magazines
- PIES
- Looking at aesthetics; style, colour, feel, space and harmony
- Image boards

#### Using briefs and specifications

- Writing design briefs
- Writing specifications

#### Generating design ideas

- Brainstorming
- Observational drawing
- Making connections
- Attribute analysis

#### Modelling

- Modelling appearance
- Modelling performance
- Modelling with computers
- Using a systems approach
- Planning tools

#### Evaluating

- Evaluating by user trip
- Evaluating by winners and losers
- Evaluating by performance specification
- Evaluating by appropriateness

From home economics teachers the Project collected the idea of identifying peoples' needs through the PIES approach. PIES is an acronym for Physical, Intellectual, Emotional and Social needs. Situations can be explored to identify the needs in these categories and products to meet these needs can be suggested – a good start to generating design ideas. Products can be examined with a view to identifying which needs they meet and how they meet them – a useful alternative to the 'what does it do and how does it work?' approach to product evaluation. Extending the range of needs that a product meets is an intriguing way of generating design ideas. From craft, design and technology teachers came the idea of attribute analysis – a powerful and active technique for using the features of an existing product to design many others. From art and design teachers came the idea of transforming one object into another, a technique which gives stimulating visuals, reveals whether students are adept at sketching, and gives practice to those who need it. Interestingly, attribute analysis is extremely useful for developing new food product ideas that sound unattractive initially but have considerable potential. Who would want a food product that was spherical, sweet to the point of being sickly, gooey in the extreme, inexpensive, unhealthy if eaten in quantity, and with a sleazy image? Nobody, that is, until you consider a Cadbury's Cream Egg!

In terms of curriculum politics for establishing a new subject to be taught by teachers from existing subjects, some of which were to be discontinued, this was a useful exercise as it gave concrete expression to their contribution to the new subject.



The Nuffield Project had tried to make the student materials appeal to a wide range of abilities, but teachers of students with special educational needs reported to the Project that their students liked the highly visual approach but became confused by the amount of information on each page. They needed it to be structured for them, just as Kimbell's research had indicated. The Project worked with a group of special educational needs teachers to produce simplified, structured materials based on the original publications to meet the needs of this particular audience (Barlex, 1997).

### Looking at what students actually do! The emerging mismatch between theory and practice

In a series of small-scale studies Welch (1996, 1998, 1999; Welch, Barlex and Lim, 2000) investigated assumptions in the literature about the strategies used by novice designers to solve a technological problem, and how students model ideas while designing and making. A review of literature describing models of the design process used in technology education suggested a discontinuity between the theoretical models, that is, models derived by thinking about what designers ought to do, and empirical models, that is, models which describe what designers actually do. This discontinuity was further supported by the classroom observations of the researcher; that students, left to their own devices, do not design in the way prescribed by textbooks (Welch, 1999). Hence the research questions which drove a first study were designed to lead to an understanding of how untutored designers go about the business of designing and making a solution to a technological problem.

In the first study, 10 Grade (Year) 7 students (six boys and four girls) were paired into five single-sex dyads. Each dyad was provided with a copy of a design brief that described the technological problem to be solved. The problem, entitled 'Paper Tower', read as follows:

Using ONE sheet of 220mm x 280mm white paper and 100mm of clear tape, construct the tallest possible tower. You will also be given pink paper. This you may use in any way as you develop your solution. However, NONE of the pink paper may be used in the tower you submit as a final product. Limitations: There is a time limit of one hour. The tower must be free standing. It cannot be taped to the floor nor to anything else. When you have finished, the tower must stand for 30 seconds before having its height measured.

Analysis of the data made evident five significant differences between modelling as described in the literature and as used by subjects. First, three-dimensional modelling largely replaced two-dimensional modelling. Second, subjects developed solutions serially rather than producing several solutions at the outset. Third, three-dimensional modelling was used to manifest not only existing ideas but to fuel new ideas. Fourth, modelling was used to develop and also to refine ideas. Fifth, models were evaluated not only upon completion but also from the moment that designing and making began.

Kimbell has identified the 'three ideas paradigm' that pervades much of technology teaching and formalises the development of several solutions from the onset (Kimbell 1997: 21). The Nuffield Project has produced materials that provided a suite of strategies students could use as and when they are needed for generating and developing design ideas (Figure 5). These strategies place no undue emphasis on sketching or the need to produce several solutions initially. Clearly there was emerging a resonance between the approach to making design decisions being developed by the Nuffield Project and the findings of Welch's research. The authors of this paper met at the International Conference on Design and Technology Educational Research (held annually at the University of Loughborough, England) in 1996 and heard each other's presentations. The resonance was confirmed through later discussions, with the result that David Barlex was invited to Queen's University for two months in October and November 1996 as a visiting scholar funded by a Royal Bank Fellowship. During this time the authors explored with teacher candidates a new model for technology education, and used this to write a policy document for math, science and technology education at the faculty. Both the model and the policy document were informed by the Nuffield Project's approach to pedagogy. This pedagogy is predicated on the use of tasks for particular learning purposes. It is based on the use of Big Tasks and Small Tasks. The Big Tasks are designing and making assignments in which children have to design and make things that are useful, both to them and for other people. Clearly children cannot be successful in this endeavour unless they have been taught relevant knowledge, skill, and understanding. The Small Tasks in each unit of work have been designed to help children learn this so that they can be successful in the Big Task (Barlex, 1998).

During the time of the Royal Bank Fellowship the presenters discussed ways of developing Welch's original research. An obvious



extension was to use a different task put into a more realistic situation, as indicated by the Nuffield Design and Technology project and the APU research. Funded by a Queen's Advisory Research Committee (ARC) grant, new research investigated whether the strategies used by novice designers are dependent on the nature of the task? The data from this follow-up study confirmed the findings of the first study. Both studies show that significant differences exist between the strategies used by novice designers and theoretical models contained in many textbooks and curriculum documents. These results suggested that teachers must think carefully about the way in which students are expected to generate, develop and communicate their design proposals.

The success of this research led to a second ARC grant in 1998/1999 that built the Nuffield Big Task/Small Task approach into the research design. The purpose of this study was to investigate the effect of instruction in two-dimensional modelling skills on the ability of novice designers to produce a solution to a technological problem (Welch, Barlex and Lim, 2000). The study addressed the questions: Does teaching two-dimensional modelling enable Grade 7 students to better express their ideas and organise their thoughts? What role does discussion play in students' attempts to generate a design proposal? Does the use of contextualising items make a difference to students' success with designing?

Eight Grade 7 students were drawn from each of two classes. One class received instruction in sketching; the other served as a control group. Each group of eight students was divided into single-sex dyads. The eight dyads were videotaped while producing a solution to a common design brief: Design and make a toy or game that will amuse and intrigue a bed-ridden hospital patient aged approximately 12 years and that can be played with on a bed tray.

As in the earlier studies, students did not view sketching as a mediating instrument between mind and hand, between thinking and doing. This is perhaps not surprising, because although design professionals use sketching as a means of thinking they are already highly skilled and fluent in its use. Students, on the other hand, are of necessity likely to have limited skills and insufficient experience of sketching to be fluent. It is important that this lack of skill is not permitted to inhibit students' ability to generate, develop and communicate design ideas. The data also showed that students take action themselves to resolve this dilemma by moving straight to

three-dimensional modelling when this is possible. In addition to the type of modelling techniques used by the students this study suggested their ability to generate, develop and communicate design ideas is enhanced by both the dynamic relationship between students' talk and three-dimensional modelling and the way the task is contextualised (Welch, Barlex and Lim, 2000).

The results of the APU research and that occurring in Ontario, combined with the approach developed by the Nuffield Projects, prompted the authors to investigate the relationship between curriculum development and educational research (Barlex and Welch, 2000). In addition, evidence from a four-year study in England, showing that 'pupils' attainment in designing lags behind that in making ... because pupils are either not introduced to a sufficiently wide range of designing strategies ... or are not taught to use them effectively' (Office for Standards in Education, 1998: 17) further encouraged the authors to investigate ways in which educational research could support the development of curriculum materials to teach students to generate, develop, and communicate design ideas.

### **The influence of the writings of David Layton on secondary Nuffield design and technology**

David Layton, Emeritus Professor of Education at Leeds University, was a member of the working party, chaired by Lady Parkes, responsible for writing the report that informed the first set of National Curriculum Orders for design and technology in England and Wales (Department of Education and Science, 1988). Since then David has written widely on design and technology education, particularly with reference to the relationship between science and technology. He explains that the scientific tradition constructed an ideal world

*'a mathematical 'shadow world' of points which occupied no space, of material bodies unblemished by departures from perfect rigidity and glabreity and for which linear inertial motion (or rest) was the norm, of fluid media untroubled by turbulence or eddies, and of a space which was homogeneous and isotropic. In this abstracted world there was no intrusion of those scale effects which disconcerted engineers and with which Galileo had once wrestled ... The same laws of mechanics described events on both a terrestrial and celestial scale.'* (Layton, 1991: 45)



Layton compares this to the world of the technologist, using the ideas of John Staudenmaier (1985) on the relationship between scientific and technological knowledge. According to Layton (1993), Staudenmaier holds that:

'Technological knowledge is to be understood as knowledge 'structured by the tension between the demands of functional design and the specific constraints of its ambience.' Design concepts cannot remain on the abstract level, but 'must be continually restructured by the demands of the available materials, which are themselves governed by further constraints of cost and time pressures and the abilities of available personnel' (p.104). The integration of 'the abstract universality of a design concept and the necessarily specific constraints of each ambience in which it operates' would seem to be the primary cognitive problem of technological knowledge.' (p. 51)

Layton agrees, writing: 'solving technological problems necessitates building back into the situation all the complications of 'real life,' reversing the process of reductionism by recontextualising knowledge' (Layton, 1993: 59). This theme recurs throughout the literature. Scientific knowledge needs to be transformed before it can be useful to designers and engineers.

The Nuffield Design and Technology Project took note of these warnings, and produced summaries of technical information designed specifically to help students make design decisions (Barlex, 1995b). These 'Chooser Charts' can be used by teachers to support making design decisions by students from a wide range of ability (Figures 6 and 7).

All teachers have been in the situation where a student has presented a design idea that is seriously flawed. What does the teacher do? There are two extreme responses: Explain what is wrong and provide an alternative design that is not flawed, or sanction the idea in the belief that the student will learn a lot when the flaws reveal themselves. Neither response is satisfactory. In the first, the student has a design that will work at the expense of losing ownership. In the second the student retains ownership at the expense of considerable disappointment and possible demotivation. A middle way is clearly desirable. This is where Chooser Charts play an important role. They contain, literally, dozens of solutions to design problems. Using a chart as the basis for careful questioning, the teacher can lead a student to identify the flaws in an existing design idea AND propose alternative improved ideas. The charts also



Figure 6: Fastening chooser chart.





provide a powerful mechanism for differentiation. The sorts of questions teachers use to get a student to make best use of a Chooser Chart can be adapted for students of different ability. With students of limited ability it might be a case of using the chart to identify just one viable design idea. With a much more able student a teacher can use the same chart, but different questions, to elicit several plausible design ideas AND some criteria that the student can use to choose the one most likely to be successful.

#### Curriculum development projects commission research to explore pedagogy

Concurrent with the small-scale studies in Ontario described earlier, the Nuffield Design and Technology Project had commissioned independent research by Patricia Murphy of the Open University into the use of the Big Task/Small Tasks approach to teaching technology in elementary schools. Murphy's research found that the approach provided a robust and effective pedagogy that was of use to both experienced and novice teachers because it provided a structure that the student could understand and the teacher could use flexibly. She also noted that it might provide a pedagogy suitable for use in elementary science lessons (Murphy and Davidson, 1998). One of the key insights into the effectiveness of the Big Task/Small Tasks approach made by evaluators was to make explicit the necessity to see the learning from the Small Tasks as providing students with the knowledge, skill, and understanding to make the design decisions required in the Big Task. This enabled the authors of the tasks to have a much clearer view of the purpose of the tasks; their content were no longer driven by syllabus requirements but by a consideration of the decisions the students were likely to have to make.

**Young Foresight** is a curriculum development initiative in which students in Grade 9 are given the opportunity to work co-operatively to conceive products and services for the future in consultation with mentors from industry using Foresight principles. These principles include identifying possible future scenarios, appreciating existing and potential markets, utilising new and emerging technologies, responding flexibly to changes in global and local economies. **Young Foresight** tasks require students to anticipate future trends and consumer behaviour and create ideas for products and services that will perform well in a world that hasn't yet arrived.

Patricia Murphy has been commissioned to evaluate the initial trials. Her findings are encouraging:

*'The Young Foresight approach challenges the definition of the design and technology curriculum and its traditional approach to teaching. This approach has design always linked to, and restricted by, the requirement to make which in turn is restricted by the resources available and the creativity of the teacher. A feature of design and technology is the motivation pupils experience when engaged with it. Pupil motivation is attributed to the practical nature of the making activity and the outcome of an individual pupil product. Consequently individual, practical work is seen as an essential feature of practice in design and technology. Young Foresight's focus on design without making and group rather than individual outcomes can therefore be seen to be in conflict with good practice and very daunting for teachers and pupils alike. This, however, is not the case. Teachers comment on their pleasure and surprise in the success of their implementation of the Programme.'* (Murphy, 2000: 1)

Murphy also reports that 'the considerable challenges that Young Foresight brings were well met by the students. They were not less motivated, but more motivated than in previous lessons. Group work was seen as a positive benefit. One student reported:

*'You get a better product as a group. You don't get 'Ah, you're doing this wrong'; they help you out and say you could have done this ... help you evaluate your product sort of.' And a second student said, 'You're not just like 'do this, do that'; you've got more ideas to do it. More opportunity.'* (Murphy, 2000: 3).

The research is demonstrating very clearly the success of a curriculum development initiative and putting it in the context of its challenge to the prevailing orthodoxy.

It is clearly important that new entrants to the profession are made aware of the contribution educational research can make to informing curriculum development and good classroom practice. The Nuffield approach to teaching design and technology informed by research and itself informing research activity provides a powerful means of engaging new teachers with educational research, as described in the following section.



### Closing the gap: Teachers' use of research in classroom materials development

Twenty teacher candidates from Queen's University in Ontario, meeting for three hours on three consecutive days, were introduced to the Nuffield approach to teaching design and technology, in which capability is demonstrated through the completion of a Capability Task (a Design and Make Activity) and enabled through supporting Resource Tasks. The teacher candidates then participated in the development of a Capability Task and supporting Resource Tasks using the same design brief as the pupils in the research described earlier in this paper.

On Day 1 the teacher candidates were given a workbook designed to

- introduce them to the Nuffield approach and the research findings
- involve them in the development of a Capability Task and supporting Resource Tasks
- prepare them to complete some Resource Tasks and the Capability Task.

The workbook opened with a copy of the context and design brief (design and make a toy or game that will amuse and intrigue a bed-ridden patient approximately 12 years old and that can be played with on a bed tray) from the research studies referenced earlier. This was followed by a series of questions.

- What learning about designing will be important for the pupils to be successful?
- What learning about making will be important for the pupils to be successful?
- What learning about technical matters will be important for the pupils to be successful?
- What learning about other matters will be important for the pupils to be successful?
- What design decisions (about the product, the user, the performance, the appearance of the product, how the product will work, how it will fit together, and the materials, adhesives, fixings and components required) will the pupils make?

Teacher candidates were also required to consider whether or not the task statement and design brief needed to be developed in more detail, and what performance specifications should be provided to pupils.

The next step required teacher candidates to identify the knowledge, skills and understanding pupils would need in order to

be successful in the Capability Task. This led to the identification and development of a series of Resource Tasks to teach simple designing skills, construction skills and technical understanding. Finally, teacher candidates were asked to identify opportunities for using information and communications technology and to consider assessment issues.

Working in groups of four, teacher candidates then completed the workbook. At the end of the first day the authors collected the written responses from the teacher candidates. These were collated and written into a second version of the workbook.

On Day 2, teacher candidates used the second version of the workbook as a basis for discussion as they worked in dyads on a selection of the Resource Tasks and the Capability Task. Prior to this activity the two authors had resourced the room with tools and materials required. Teacher candidates each completed two Resource Tasks as individuals before working with a partner to complete the Capability Task. The authors provided technical assistance with practical work and engaged in individual discussion. As a result, a variety of toys and games was produced by the teacher candidates, including a tabletop pool table, a marble maze, tabletop basketball, and several board games (Figure 8).

At the end of Day 2 the authors were able to develop a set of questions to help teacher candidates reflect on their work. The questions focussed on:

- the Resource Tasks (e.g. Which resource tasks did you complete? Did they help with the Capability Task? What difficulties did you have when tackling the Resource Tasks? What difficulties might your pupils have?)
- the Capability Task (e.g. How did you generate ideas for the toy or game? How did you record these ideas? How did you develop these ideas?)
- the product (e.g. Does it meet the performance specification? Are you proud of it? Given more time what improvements would you want to make?)
- Assessment (e.g. What do you think you learned? What is the evidence for this learning?)

On the third and final day the teacher candidates, working first individually and then in pairs, developed answers to these questions. A closing tutor-led discussion resulted in a series of conclusions about:



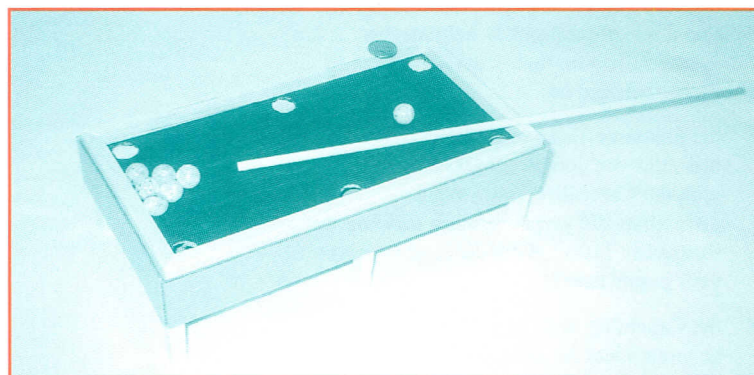
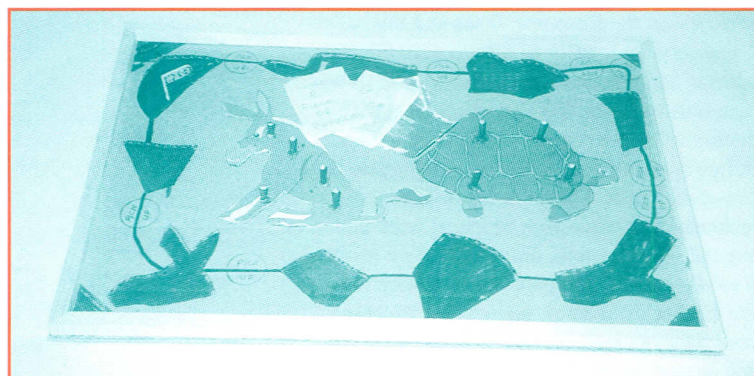
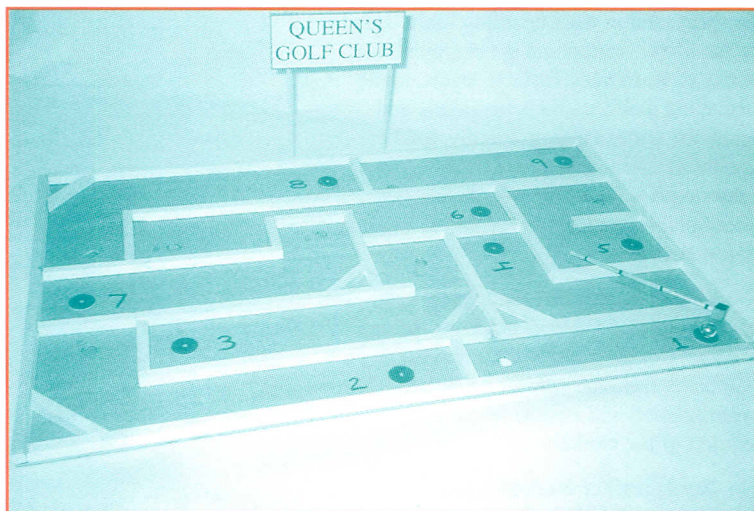
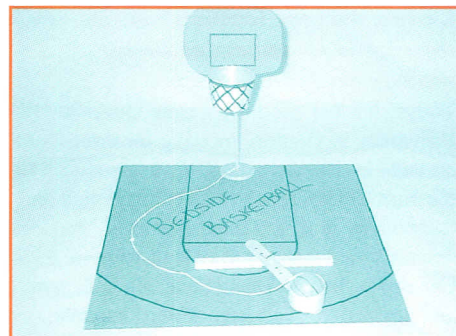


Figure 8: Toys and games for a bed-ridden child.

- a) using the Nuffield model in the design and technology classroom
- b) curriculum materials development
- c) using research findings to inform classroom practice.

For example, teacher candidates reported a significant level of confidence as they tackled the Capability Task. When questioned they were able to identify their success with the Resource Tasks as contributing significantly to this confidence. They also reported 'getting better at design decision making' and 'learning new making skills' as a result of completing the Resource Tasks. Conversation



around the organisation and resourcing of the three days highlighted for teacher candidates the critical importance of the effective deployment of resources. The interaction between the instructors and the teacher candidates while they were tackling both the Capability Task and the Resource Tasks led one teacher candidate to identify the relationship between the teacher and the pupils in the design and technology classroom as crucial. Teacher candidates were able to articulate that if pupils are to experience success as they engage in the risky business of developing a design proposal, there must exist a significant level of confidence in and trust of the teacher. Finally, participants identified the discontinuity between descriptions of the linear design process in many textbooks and curriculum documents and the iterative process identified by empirical research.

### Conclusion

Technology education is increasingly an established part of the school curriculum throughout the world and in many countries, including England and Canada, designing and making is a central feature of the technology curriculum. It is both intellectual and practical. It introduces children to the powerful process of designing; a process in which new ideas are conceived and taken from the mind's eye into the made world. It requires creativity and problem-solving abilities. It develops hand-eye co-ordination in the precise use of tools and materials. It fosters the ability to make decisions, plan a course of action and carry it out working as an individual and as a member of a team. But it has an even bigger role to play in children's education. It develops their cognitive skills. Through designing and making children learn to think.

The curriculum development that has informed technology education has often been intuitive and derived from emerging best practice rather than a consideration of research findings. However where curriculum development in technology education has been informed by research then the resulting pedagogy and associated classroom materials



have stimulated effective practice on a large scale. And some research is beginning to challenge prevailing orthodoxy.

It is clear that the promise of technology education evidenced from practice that is only just beginning to be informed by research leads to the conclusion that with more research this promise can be considerably enhanced. When we really understand how to construct a technology education experience that empowers students to make design decisions then we will be in a position to help technology education fulfill its potential. The emerging research agenda is wide but we are particularly interested in the nature of tasks that can be used to teach students particular facets of designing and how the learning from such tasks can be used by students to develop integrated capability.

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