

A Pilot Study into the Value of 3-D Sketch Modelling at Key Stage 3

Abstract

Modelling is fundamental to design and technology. From the initial image in the mind, a cognitive model, right the way through until the final product designers use models. They can use drawings or sketches, 2-D modelling, 3-D sketch modelling or mock ups, mathematical and/or computer models, and prototypes. This paper is an account of a pilot study into the value of the use of one type of model, the 3-D sketch model, when used by Key Stage 3 pupils when designing a product to be made in the area known in the English National Curriculum as resistant materials. The pilot study was conducted at a rural comprehensive community college. The researchers first reviewed the extent of the use of 3-D sketch models by pupils in Year 9. They found that little use was made of this way of developing design ideas and solving problems. In conjunction with the school staff a revised approach to a resistant materials project was set up to include the use of 3-D sketch modelling. The pupils were required to begin by sketch modelling and then move between 3-D and 2-D design media several times during their work. Observation during the sessions suggested that the revised approach was effective and this conclusion was confirmed by structured interviews with each of the pupils involved.

The paper is intended to encourage teachers to replicate this pilot in other schools using other briefs and other materials to make 3-D sketch models. It makes a number of suggestions for materials to help teachers encourage their pupils to use 3-D sketch models in an appropriate way. It identifies 'emerging research questions' for further investigation.

Introduction

Modelling is a fundamental element in design and technology education. Although obvious, it is often overlooked that, from the generation of the first image in the mind of an idea for a new product or system through to, but not including, the actual product or system, the product is represented by models. The models have attributes of the final outcome but are deficient in some way compared with the actual product or system. The model might look visually like the final object, as in a sketch or clay model of the car, but does not function mechanically. The model might feel the same but not smell the same. The model might have the same mass but not make the same sound when the lid is closed.

In design and technology education, models not only have the role of assisting the pupil designer to develop ideas but also to enable

effective communication with others. They have a third role in education because they help the teacher to assess the progress and learning needs of their pupils. Quick initial 'rough' drawings and 3-D sketch models are often thrown away by pupils because, one assumes, they do not value them. In their minds they appear to no longer serve any further purpose. For educational reasons, however, these models are valuable for showing the development of thinking.

In the DATA Annual Lecture at the NEC, John Smith (2001) looked at the current and future role of modelling in design and technology. He emphasised the importance of modelling and, in particular, was of the view that currently in education the 3-D sketch model or mock up was undervalued, especially as a method for pupils to develop innovative ideas. He had observed reluctance by many undergraduates to use 3-D sketch models and yet, not only is this method used by professional designers, but once the students began modelling in 3-D, ideas appeared to flow. Modelling media are not adequately understood from a teaching and learning perspective. There is scope for a large amount of research in the area of modelling, including comparative research.

The Department of Design and Technology at Loughborough University has set itself the task of opening up this field of modelling. Some years ago it brought out a number of publications identifying the key importance of modelling (particularly Roberts, Archer and Baynes, 1992). It now plans to undertake further research into the role of modelling when designing both in education and in professional practice. The interaction between ICT and design and technology, especially in CAD/CAM and rapid prototyping, is also high on the Department's research agenda.

In taking up the issue of 3-D sketch models, it was decided to focus initially on their use by Key Stage 3 pupils. In the implementation of the design and technology English National Curriculum the accepted approach appears to be in many cases 'Draw then make'. This is a linear sequence running from 2-D directly to a final product. Many educationalists would be surprised if this was the best sequence. In the case of younger children it is well established that the 'concrete mode' of thinking using physical materials is very accessible. While it is acknowledged that many teachers do encourage their pupils to undertake 3-D sketch modelling, there are many who do not. If the benefits of using 3-D sketch modelling in education were proven then all teachers of design and technology could be encouraged to require their pupils to use them.

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Table 1: The value of sketch models in the educational design process.

Basic propositions

- That cognitive modelling is the fundamental mental process that enables people to conceive of (or imagine) future places, products and communications.
- During design activity, people use cognitive modelling in a dynamic relationship with physical and symbolic models which are used to develop and represent design ideas and proposals. These types of modelling include:
 - Mathematical models
 - 2-D models – drawings, plans and sketches
 - 3-D models – including sketch models, appearance models, mock-ups
 - Prototypes and patterns
 - Digital models.
- In professional design activity, specific areas of designing have developed particular forms of modelling (scale drawings, clay models, and book dummies for example) and these are usually directly linked to the production process in that particular field.
- In fields of 3-D design, including engineering, architecture, product, fashion and textile design, the use of 3-D models is particularly valuable in enabling the designer to conceptualise and visualise the future 'product' in more completely. In particular, the use of '3-D sketch models' as a conceptual tool appears to be an important feature of the early stage of developing design ideas.
- In general education, the use of 3-D models is particularly valuable because it relates to the 'concrete' nature of children's thought and provides a realistic medium in which to explore design ideas. However, the use of sketch models appears to be underdeveloped in spite of its evident value to 'student designers'.
- It seems reasonable to argue that children and young people (who inevitably lack a wide experience of design ideas) would find it easier to design if they made more use of 3-D models while designing.
- Using 3-D models – particularly sketch models – may help to solve a range of specific pedagogical and developmental problems.
 - by-pass problems with drawing which sometimes limit students to proposing only those designs that they feel able to draw
 - encourage the consideration of different possible resolutions of the 'design problem' which enables students to take a more imaginative and open-ended approach
 - enable pupils to visualise their ideas more realistically
 - enable design proposals to be evaluated more fully during the development of the design both by the student and the teacher
 - highlight the importance of '3-D factors' such as shape, identity, control, mechanisms, materials, accessibility, person-product interaction, marketability. Ergonomics – aesthetic qualities, psychological and behavioural patterns/choices.
 - make it easier for pupils to have a realistic discussion with others. This would include the teacher, 'users' and any outside advisors consulted during the design work. The 3-D sketch model brings the product 'alive' and gives it reality.
 - provide a focus for assessment during the development work
 - provide a record of the pupils' changing ideas and proposals.

Discussing an older age group, Malcolm Welch (1998) found that a group of Grade 7 pupils in Canada went immediately into 3-D modelling when designing. In a follow up to this study Welch, Barlex and Lim (2000) found that even when they included teaching of 2-D sketching first, the pupils still went straight to 3-D modelling. In an unpublished paper on working with sixth form students at Oakham School, Baynes and Brochocka found that it helped A' Level students to visualise the functioning of mechanisms if they first modelled them in easily worked materials. John Smith (2001) reports that:

'Time and again it has been observed that undergraduates have been unable to generate further new ideas while using sketching but once they move to 3-D sketch modelling, their ideas start to flow again.'

This paper describes a pilot project carried out as the prelude to a wider research programme. The aim is to highlight and explain the educational value of 3-D sketch modelling. 3-D sketch models are quick models made from any readily available material, such as card, wire, wood, fabric, plastic foam, Plasticine, clay etc., that enables initial ideas in the mind or in a 2-D sketch to be produced in a 3-D form either full size or to scale. Clearly many of the attributes of the product are missing in a 3-D sketch model such as perhaps the correct colour, the same finish, the correct mass etc., but it does give the designer, the client, the user and/or teacher, a better idea of the 3-D aspects of the final product. It may lead to detailed curriculum development activity and, if appropriate, publishing teaching materials. The aim of the pilot, therefore, was not to come to conclusions but to identify more clearly the key questions and to propose ways of investigating them.

Approach

At the outset, the researchers set out a number of 'basic propositions' that would give a sense of direction to their enquiries (Table 1).

There were three aspects to the pilot:

- a literature survey and review, covering education and the uses of 3-D sketch modelling by professional designers
- field work in an East Midlands school
- a structured interview questionnaire with pupils.

This paper reports on the field work and those aspects of the structured interviews directly related to 3-D sketch modelling. The fieldwork took place at Uppingham

Community College, a rural comprehensive school situated in a small market town. It focused on the Year 9 design and technology curriculum which operates a form of 'circus'. Each group of approximately 20 students experience four areas of work during the year. The areas are materials based:

- textiles
- ceramics
- resistant materials (in this case, wood)
- computer graphics.

Each of these areas is studied for eight weeks. The timetable allocates one double lesson (2 hours) and one single lesson (1 hour) per week.

During the first eight-week session the researchers observed lessons in all areas. In the second eight-week session they intervened in the resistant materials area and taught alongside the class teacher. The aim was to introduce new work based on 3-D sketch modelling and, particularly, to test the potential of 3-D sketch modelling as a medium for developing design ideas.

The initial period of observation showed that a variety of modelling media were in use but that the students largely developed their design ideas through drawing and looking at the work of previous students. Table 2 summarises these observations.

It was interesting to note the use made of card models in the resistant materials area. Scale models were used to help the students prepare for the production of their table designs in medium density fibreboard (MDF). It was clear that the card models were helpful in enabling the students to make the best use of their material and to foresee the detail of the structure they had envisaged. In at least one case (see Figures 1-3) it is hard to see how the student could have succeeded without the use of the scale model. This very clever design depended on the accurate interlocking of the components on the MDF sheet and with each other.

In intervening in the resistant materials area, the researchers decided to build on this use of card and to use thin card as the material for 3-D sketch modelling. They also decided to introduce its use very early in the sequence of lessons. To help the school develop its links with industry it was agreed to involve an outside company – IKEA – in the students' final presentation. It is not thought, however, that this additional factor had any influence on the students' use of and reaction to 3-D sketch modelling.

Table 2: Summary of observations – uses of modelling media and sources of design ideas in the materials based areas.

Textiles (Hats)

Modelling media: drawings, pattern making.

Sources of ideas: library search; Internet; previous students' work.

Ceramics (Teapots)

Modelling media: drawings, scale model in clay.

Sources of ideas: investigation of work by Clarice Cliff.

Resistant materials (Flat-pack tables)

Modelling media: drawings, scale model in card.

Sources of ideas: observations, Internet, previous students' work.

Computer graphics (Board games)

Modelling media: on-screen graphics package.

Sources of ideas: personal experience of games, pop art, Internet.

Note: All projects were defined by the outcome, e.g. 'A hat for a particular person', though students were encouraged to find an individual design within that very general framework.

Table 3: Flat-pack table project. Principles adopted by the researchers.

- To emphasize the role of the designer in serving the needs and wants of a particular market.
- To emphasize the importance of imagination and originality in the designer's work.
- To encourage a certain amount of group working with discussion stimulated by the presence of 3-D sketch models.
- To begin with physical 3-D sketch modelling and to return to it at various stages in the project, encouraging a degree of fluency between 2-D and 3-D modelling media.
- To talk about 'thinking about thinking', emphasizing creative thought processes such as 'seeing in the mind's eye', imagining and visualizing, hoping to help students to recognise their own use of these abilities.

Table 4: Flat-pack table project. Brief.

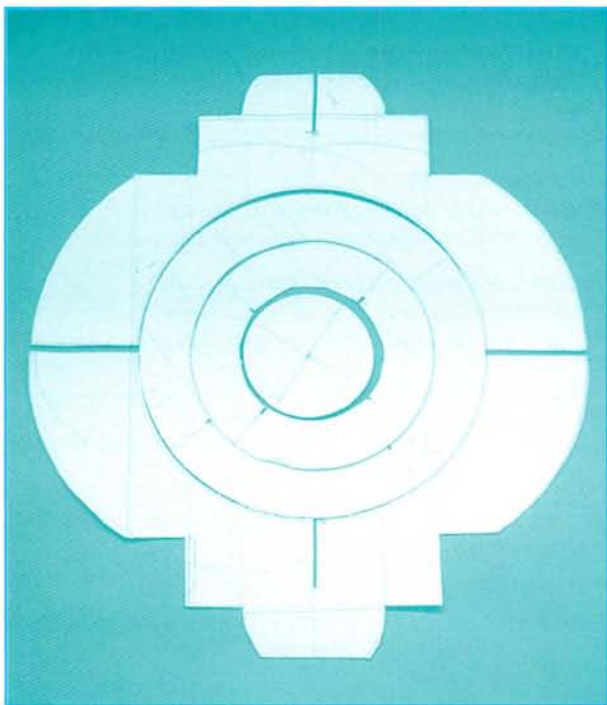
IKEA are looking for a new product range of low-cost flat-pack furniture for young people.

They wish to begin with a prototype/scale model for a small table. This will show what the new range will be like and be used for market testing.

IKEA wish to know the most promising age range for the new products.

There are limitations. Manufacturing costs must be low.

- Only use the specified quantity of MDF (600 x 600 mm).
- Only use two manufacturing processes – sawing and routing.
- The table must slot together.



Figures 1, 2 and 3.

A complete list of the principles adopted by the researchers is given in Table 3. The brief given to the students is in Table 4.

Whereas, in the 'normal' pattern of work, the students began in 2-D and continued 'on the flat' until very nearly at the production stage, the pattern of modelling activities would now be:

1. 3-D sketch modelling – 'playing' with the material and structures
more developed 3-D sketch models
2. various kinds of 2-D sketch drawings
3. 3-D card modelling of the selected design
4. card patterns to scale
5. marking out on the MDF
6. making.

In summary the work went through the following stages (some of which of course covered more than one lesson):

- **Creativity game**

Take a piece of card and by cutting, bending and slotting make a flat-topped structure. Share the results, making a mini-exhibition of the variety of structures that were made.

- **Raising awareness of tables: form and function**

Talking about 'table-ness'. What are tables for? Who uses them?

- **Developing first ideas**

Design exercises: drawing, modelling and collecting.

Working with card: cutting, folding and slotting.

Looking at existing tables: collecting images.

Thinking about what already exists: drawing from memory, flat-topped structures around the house.

- **Introducing and understanding the brief**

Analysing what the brief means.

Discussing the role of the designer.

- **Exploring the market**

Select an age group.

Being aware of their needs and wants: creating a concept board.

- **Getting further design ideas**

Sketching 12 ideas and selecting one.

Making a card model of the selected idea, using only cutting and slotting.

Figures 4, 5 and 6.

- **Learning about MDF**

Qualities and characteristics of MDF.

Advantages and constraints.

Introduction to the processes and skills involved in sawing, routing and finishing MDF.

Importance of safe working practices.

Planning making as a step by step process.

- **Developing the design**

Considering the design in the light of the advantages and constraints of MDF, modifying the design as necessary.

Revising the 3-D model, making a new model if necessary.

Learning how to mark out the design on the MDF.

Learning how to use centre lines to guide the router and achieve an accurate fit.

- **Making the table**

Sawing using hand tools and jig-saw.

Routing.

Finishing using a variety of tools.

Achieving a good fit and a smooth finish.

- **Colouring the table**

Learning about wood stain.

Thinking about the role of colour.

Making decisions about colouring the parts of the table.

Applying the wood stain.

- **Contributing to the presentation**

Making final adjustments to the prototype or model.

Completing the paperwork for the project folder.

Taking part in the presentation to IKEA.

- **Evaluation**

Considering if the design fulfilled the brief.

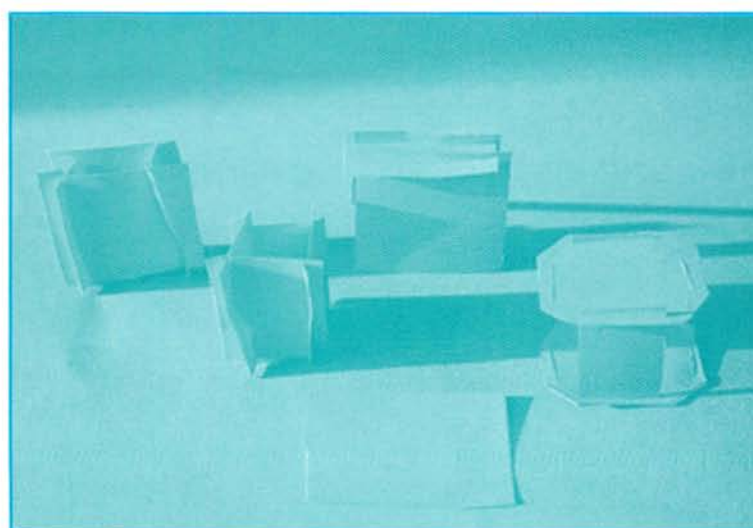
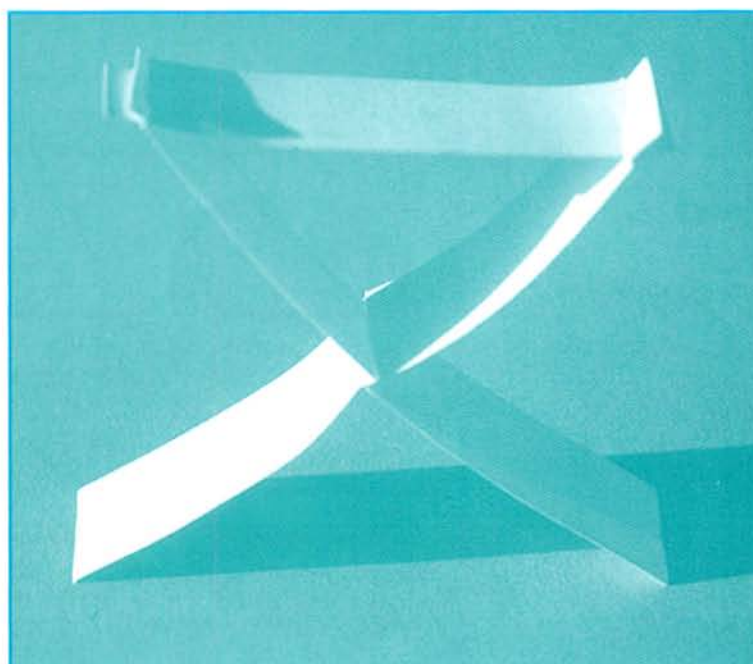
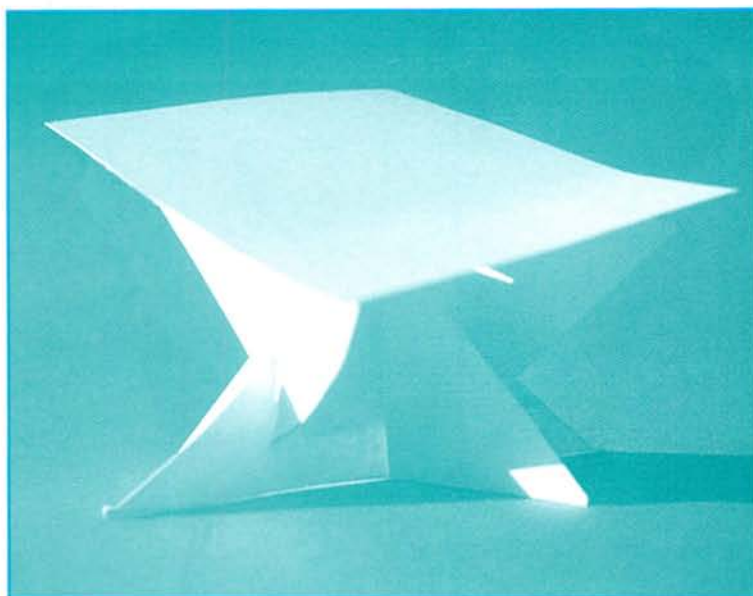
What new ideas and skills were learnt?

Reflecting on personal reactions to the project.

What has been learnt that can be applied in future projects?

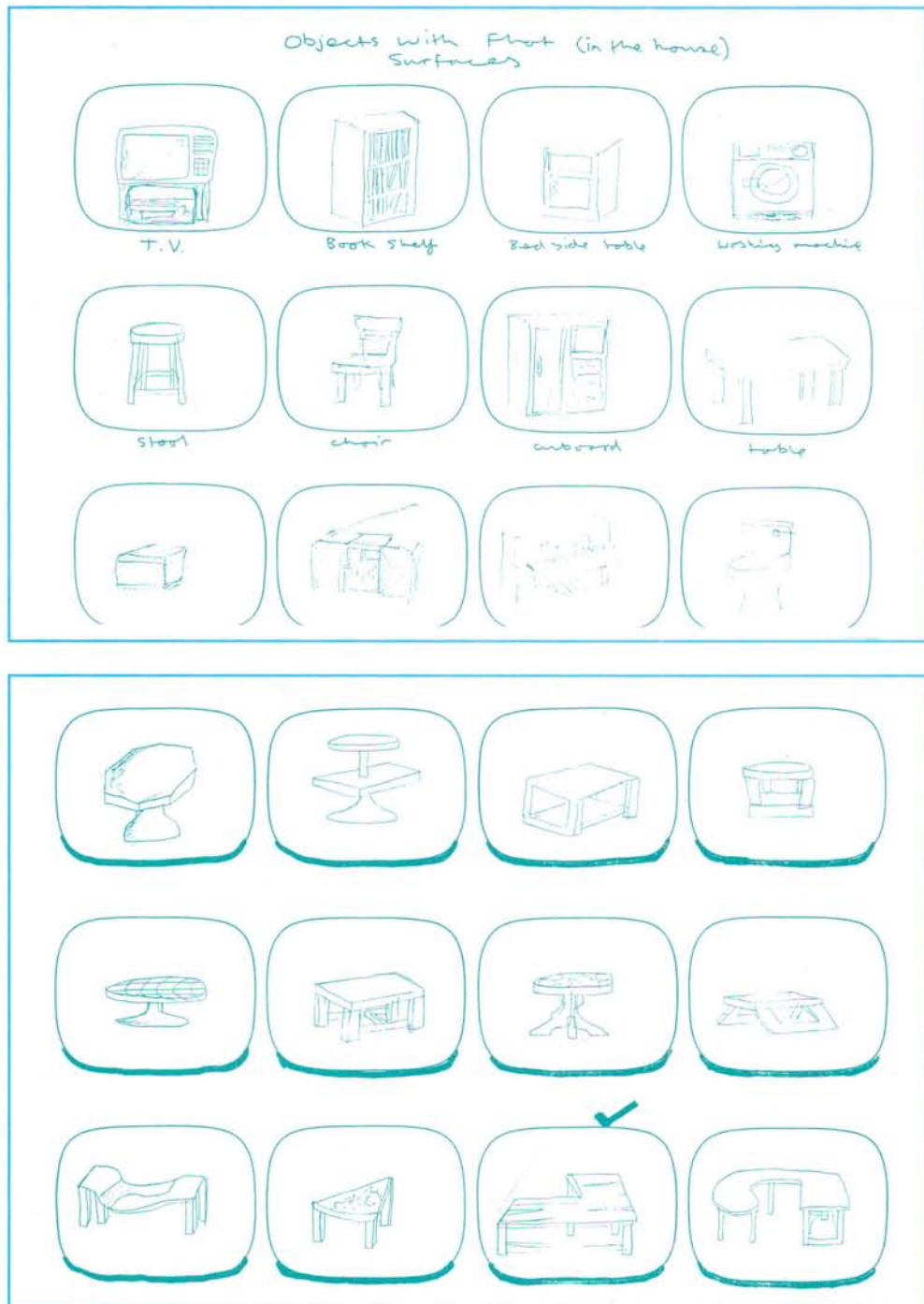
Answering the researchers' questionnaire in a structured interview.

It is important to note that the sequence was to some extent reiterative. For example,



Figures 7 and 8.

RESEARCH



although there was a formal evaluation at the end, each stage of work was evaluated through discussion as it happened. Developing ideas happened throughout. The importance of the market and the needs and wants of the target age group formed part of the discussion at every stage once the brief had been introduced.

There were always two and sometimes three researchers in the classroom (the resistant materials workshop). The class teacher took part as a participant researcher. A technician was available to assist in the practical making sessions and played an important part in helping the students realise their designs.

One or other of the researchers and/or the class teacher conducted the lessons: the other researcher acted as an observer making written notes of each session. At the end of each session there was a brief review and exchange of impressions. At the conclusion of the eight weeks the researchers and the class teacher met for a lengthy de-briefing covering all aspects of the pilot.

A photographic record was kept throughout. All work by the students was preserved for subsequent review and this collection of material was integrated with the normal students' task of constructing a folder/portfolio for assessment.

The researchers believed that the first session of sketch modelling with card would be important in setting the 'tone' for the whole project and in creating a positive working relationship with the students. This proved to be the case. It was approached in the spirit of a game. Significantly one of the two researchers and the class teacher took part with the students, carrying out the same exercises on their own behalf.

The game was to 'explore what we can do with one piece of card, changing it from a 2-D sheet into a 3-D structure. We can use cutting, slotting, folding and bending. There's one extra requirement: the structure has to end up with a flat-top'.

As the researcher conducting the lesson explained to the students:

'Don't worry about going wrong. Say you're using five pieces of card, if one goes totally wrong throw it away. Of the four left choose your favourite but don't forget that some of the others will have good features. We really are learning from our mistakes as well as our successes. We are finding out not trying to produce a perfect finished result.'

We really are learning from our mistakes as well as our successes.

The thin card proved to be ideal. It did not look valuable or precious. It clearly did not matter if a mistake was made. It was easy to work using techniques that most of the students had mastered when they were infants. When all the 3-D sketch models were brought together for a group discussion, the students were surprised at the variety of models that had been made and they were interested in (and encouraged by) one of the researcher's models that was definitely a disaster. By intervening in the discussion, the researchers were able to give value to the most imaginative and 'risky' models. It was easy to discuss the merits of various structures and to demonstrate (for example) that some of the models looked better upside down or on their sides. Figures 4-6 show a selection of the 3-D sketch models and the students at work.

Figure 9.

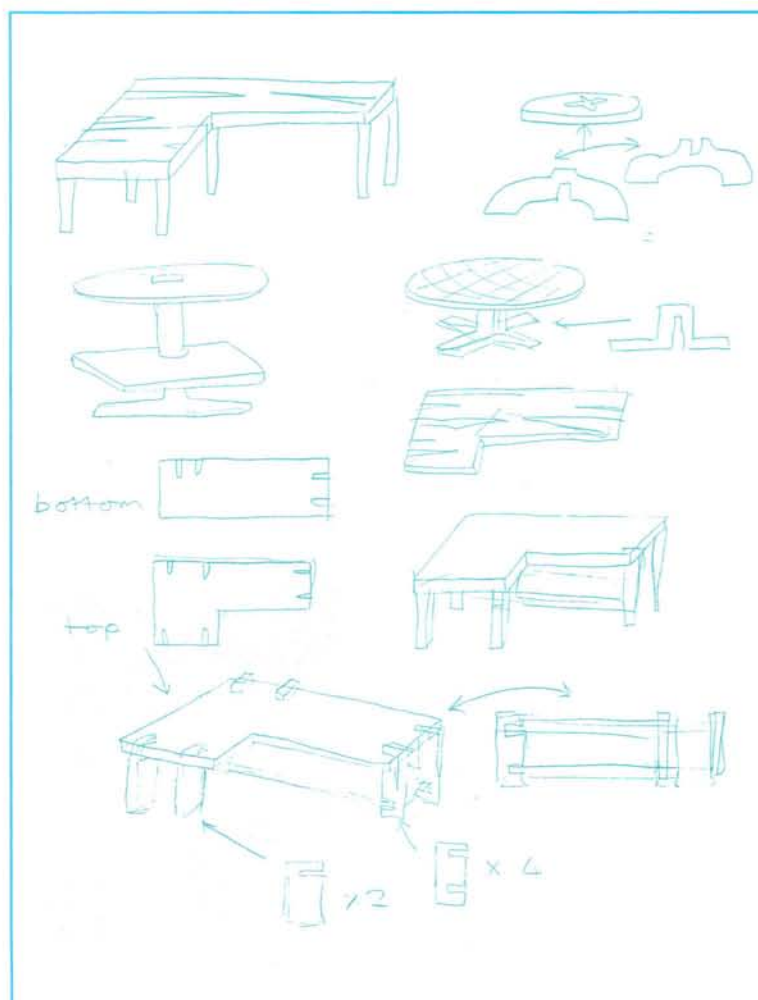


Table 5: Structured interview schedule. Part 3: About the project.

- 3.1 What did you find most difficult in the slotting project? Why?
- 3.2 What do you think you needed most help with?
- 3.3 We talked about 'seeing in the mind's eye'. Are you aware of doing this yourself? Can you give an example?
- 3.4 How did you develop your ideas? Just in the mind by thinking or visualising. By drawing or sketching. By sketch modelling with cards. Any other ways? Why do you think one way is better than the others? Do you prefer working 2 or 3 dimensionally? Why the preference?
- 3.5 Do you find it easy to talk about your design ideas and to describe what you are thinking about?
- 3.6 If you were to do this project again, what would you do differently? What would you like the teachers to do differently? Could you have done with more time? If so, at what part or parts of the project?
- 3.7 What changes would you make to your design if you could do it again?
- 3.8 What advice would you give to the next group doing this project to help them be able to make a very good product and achieve a good grade?
- 3.9 Where did the ideas for your design come from?
- 3.10 What have you learnt from this project?

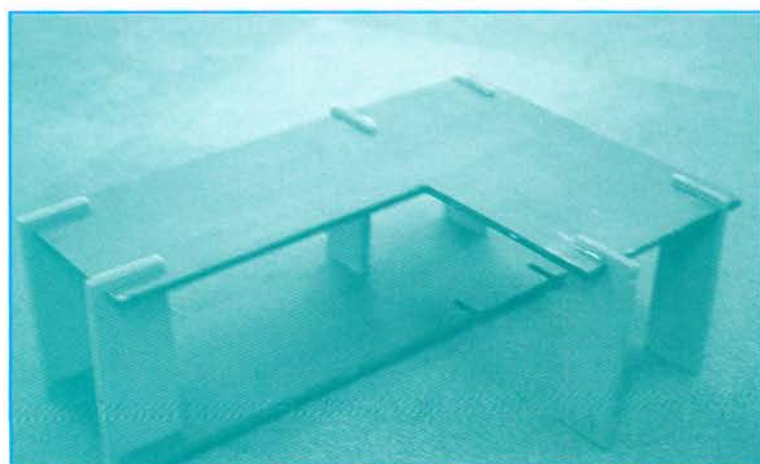
Note: Part 1 of the interviews was 'About the Student'; Part 2 'About School'; and Part 3 'About Design and Technology'.

Pupil responses

Taking the sketch modelling sequences and putting them in the context of the whole project enables some useful discussion of specific issues. These are likely to be relevant to the general question about 3-D sketch modelling, even in different fields of design activity. It was particularly useful to also have the responses from the students' structured interviews: the section relevant to 3-D sketch modelling is reproduced in Table 5. Sixteen of the 18 students were interviewed.

The questions in the Schedule were treated by the Interviewers as 'starters'. Where other interesting themes emerged, interviewer and student were free to pursue them.

Figure 10.



It seems clear that the students gained from the physical nature of sketch modelling. It is as though the material itself provided them with a source of ideas, whereas in a 2-D sketching everything seemed to be dependent on what was in the mind. This is probably not just because the modelling material behaves more like the material that will eventually be used. It might also be that the 3-D sketch model is more decisively 'out there' than the drawn sketch. We might say that the idea is more clearly realised, more visible and more accessible to the processes of judgement and change. It was also noted by Smith (2001) that students are not often taught to sketch in a form that leaves ambiguity or to look for ambiguity in their 2-D sketches. It is from ambiguity in sketching that many professional designers come up with innovative ideas.

Students made specific comments on the value of the 3-D sketch models:

- You can see all the sides of it in one model; you don't have to draw different views or imagine what its like on the other side.
- It helps you to see where it's going to be difficult to make. You can change it before you begin making.
- It's quick to do. Actually it's quite fun. I like folding and handling things.
- I had to change my design a lot. I realised it wasn't the right size for my age group. The model helped with this.
- Seeing models of different ideas helped me decide what to do. It was hard to decide which design to develop. I had lots of ideas in my drawings but the models showed me which I wanted to work on.
- It's easier to talk about your ideas if you've got a model to point to. Without it you can't always find the right words.

Analysis

It was noticeable that the students in the group had very different attitudes to 2-D sketch drawings and 3-D sketch models. They were happy with the idea that the sketch models should be rough, particularly when the class teacher and one of the researchers made their own 'roughs' along with the group. But there was reluctance to accept that rough, unfinished or untidy drawings would do the job. This attitude persisted throughout the project, even though the researchers showed examples of design sketches and their own roughs done on a table napkin in a local café.

The researchers tried to help the students use drawing more fluently. They emphasised that finish 'didn't matter' and encouraged very

Figures 11 and 12 and 13.

quick drawing by putting a time limit on the drawing exercise. To some extent the drawings, like the initial 3-D sketch models, were treated like a game. Collaging was used to supplement drawing. These approaches certainly helped. The class teacher was able to note a more relaxed approach to sketching, particularly in the 'quick' drawing exercises (Figures 7 and 8).

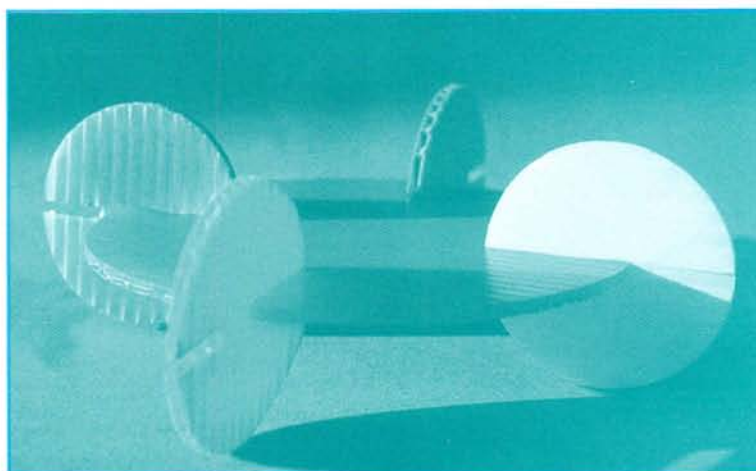
Comparing the students' drawings with their answers during the structured interviews makes it possible to recognise some revealing connections. Those few (four) who said they found drawing a good medium for developing ideas were also those who used drawing effectively throughout the project. They drew at home and liked art. The researchers only identified one case where a student (Figure 9) had made effective use of drawing to develop his design idea and explore the construction of his piece. The 2-D sketches formed the basis for his 3-D sketch model rather than vice versa and the construction depicted in his drawing was used in the very successful finished table (Figure 10). One of the girls who 'liked art' and painted at home, used drawings to great effect in her presentation, producing a particularly accomplished step by step representation of the project process.

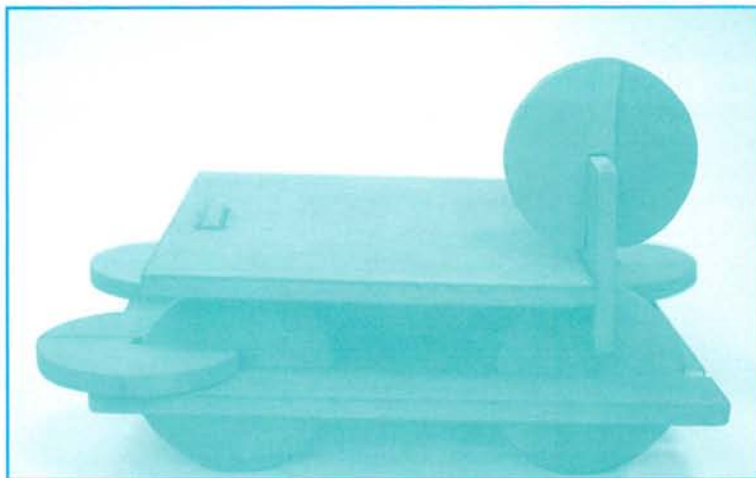
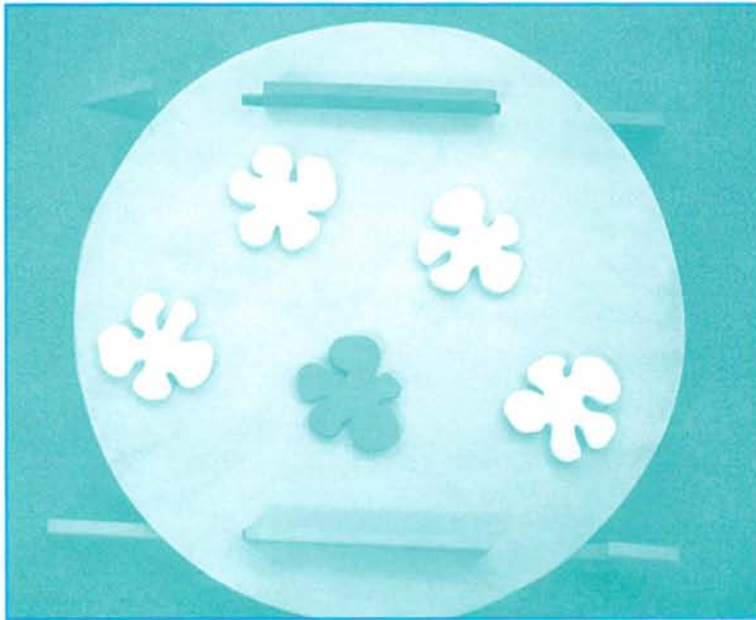
Students did not turn to sketch drawings to resolve problems during their making. However, they did frequently draw directly onto the work piece, perhaps using it as a hybrid between a 3-D/2-D sketch model and a prototype. This appeared to be particularly valuable to them. It helped them to 'see' what to do next and of course the technique is very common in all hand/tool making processes. It appears to have hardly been studied at all, yet is crucial in all practical making activities. This may well prove to be an important area for further investigation.

It seemed obvious to use thin card as the medium for sketch models of a product to be realised in MDF. As the project developed it became clear that there were other issues that should influence the final choice of modelling medium for any project:

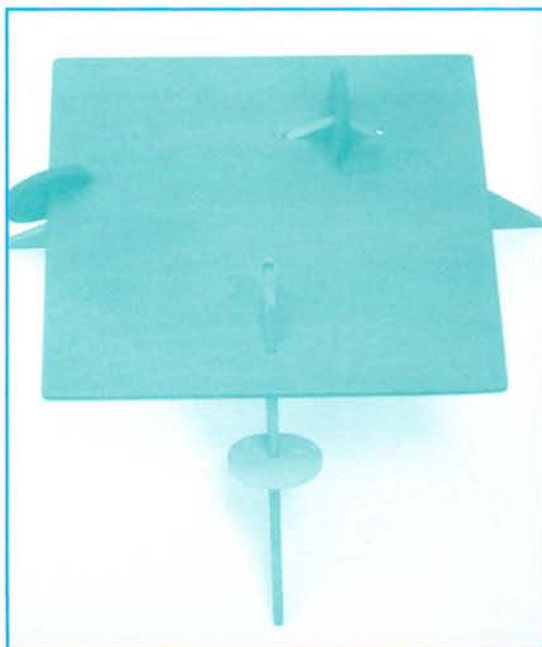
- **Weight of card**

How far should the card used replicate the stiffness of MDF? In the event the researchers adopted a very light weight material that could be folded as well as slotted (impossible in MDF). It had the advantage of being exceptionally quick and easy to work. The researchers believed that this 'accessibility' and 'responsiveness' was of greater importance than a more exact match.





Figures 14, 15 and 16.



However, it is likely that some of the problems the students later had with making can be traced back to this decision and also that some students were frustrated because not all their ideas could be realised in practice.

On reflection, the light card was probably ideal for the first exercise but it could have been replaced with a stiffer card or even thin corrugate or corrugated card for the later stages.

• **Size of card and size of models**

The card provided to begin with was postcard size. At the beginning no comment was made on the size of models and some students made very small models indeed. These were both hard to make and hard to analyse usefully. After this, students were encouraged to use one postcard size sheet per model. This resulted in models that were easily manipulated and of sufficient size to be understandable in a group discussion.

The researchers did not establish at this early stage a relationship between the size of card and the size of MDF sheet available to each student. Later there was a closer relationship but it was not until the students began on their marking out that the critical nature of the interaction of the components of the table with the sheet size became apparent.

This problem could be dealt with in two ways. It would not have inhibited the students if, from the start, they had worked with small sheets in the same proportion as the MDF. On the other hand, this may have come too early in the process to have any significance later on.

The real difficulty for the students was in trying (and failing) to understand the ‘mathematical magic’ of scaling up their designs to full-size and then marking out the MDF sheets with the correct centre lines to guide the router. A good approach would be for the students to try their setting out on a full-size sheet of light card, so producing a template. Cutting out and offering up the resulting card components would immediately reveal any inaccuracies in the centre lines. The component templates could then be physically laid out on the MDF.

• **Colour of card**

The researchers insisted on the use of single coloured card, beginning with white and moving on to red and yellow. This appears to have been a good decision. To have worked with multi-coloured models would have taken attention away from the form and structure of the design, and these were the key issues.

Current research by neuro-biologists (Zeki, 1999) suggests that the brain ‘decodes’

different object properties in different areas and that one property may cloud the perception of another. It is a commonly recorded experience that pattern may either reinforce or distract from form – this being the aim of camouflage, for example.

In an unpublished report on an exhibition workshop using Lego, Brochocka and Baynes noted that when only one colour of components were supplied, the children concentrated more directly on form and structure. Multi-colours were a distraction.

On the other hand, the researchers also had available two ready-made 'slotty' kits of parts with coloured or patterned surfaces (Figures 11 and 12). These were used to demonstrate the potential of slotting and to introduce the students to the use of unconventional shapes and constructions. In this case the colours and patterns served to identify the interlocking surfaces and to 'draw in' the components and their relationship with each other.

These influences on the choice of material only became evident as the work progressed. One of the useful outcomes of the Pilot is to highlight how important and indeed subtle is the relationship between the material used in a 3-D sketch model and its success in helping the student.

Some students made their own kits of parts. This allowed them to experiment with different combinations. In one case, a student developed four different bases for the one table top (Figure 13). Another student developed different tops for the same base. This idea of a personal 3-D kit of 'design elements' is an interesting and potentially fruitful approach. It could be encouraged as an alternative to the conventional idea of 'do three designs and choose one', having the effect of making the students' medium for innovation and experiment more independent of drawing skill.

There is also the possibility of providing the students with a ready-made kit of parts. In the present case, the researchers used their two kits to demonstrate possibilities. They were not directly used by the students to develop their own designs though they could experiment with them if they wished. It is not clear at this stage if the provision of a kit of parts would help or inhibit the development of ideas. The class teacher believes that the provision of a kit of parts would accelerate learning and enable the weaker students to explore ideas more freely. This is an interesting area for further research.

Is it possible to trace out the sources of the students' design ideas? Clearly many still

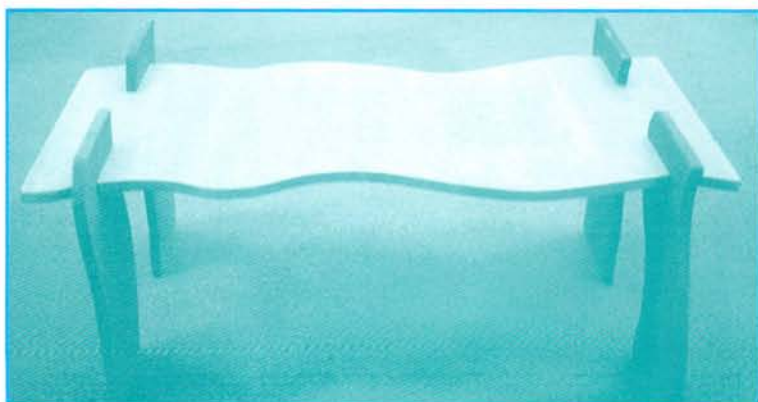
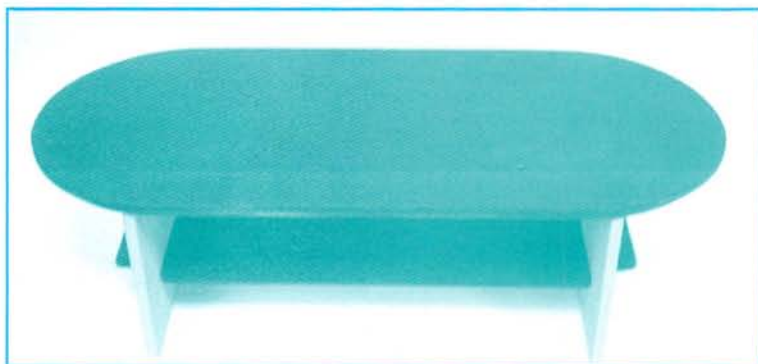
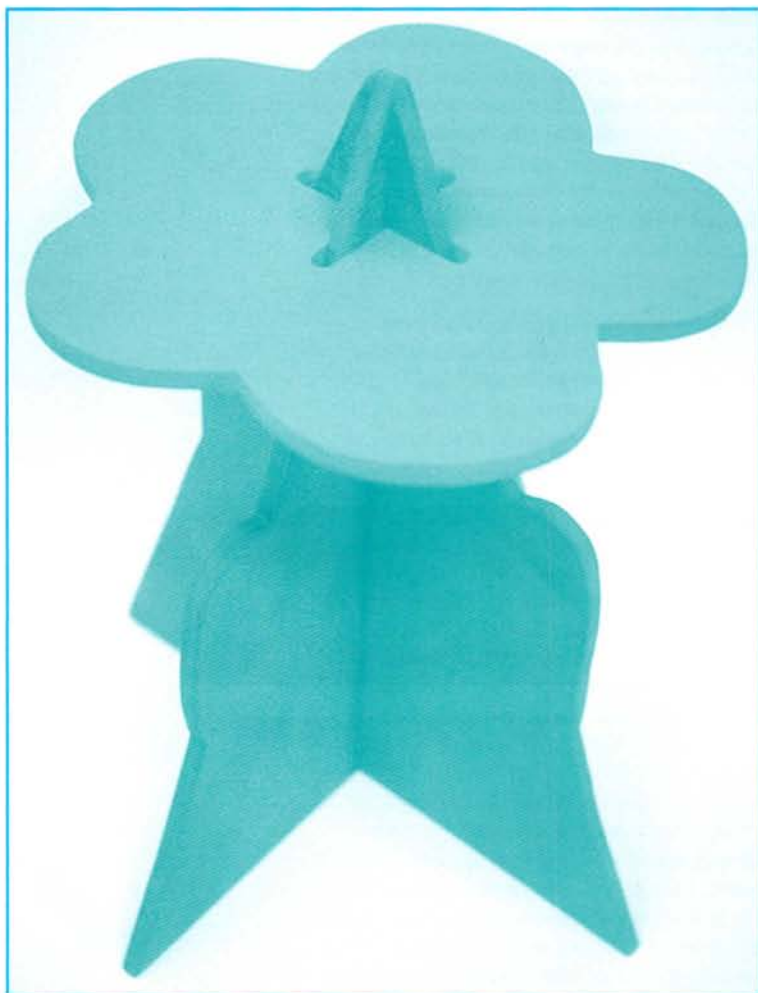
based their designs on what had been made before. It is also clear that some students were influenced by the two ready-made kits that the researchers brought into the workshop. The Pablo pieces influenced the production of designs with interesting abstract shapes and the corrugate slotty encouraged a number of designs using small slotted circles. These can be seen clearly in both sketch models and finished pieces. (Figures 14-16)

Pupils were also inspired by ideas from outside school. The exercise of identifying objects with flat-tops and collecting photographs of furniture was influential. It is possible to trace the origins of a number of the finished pieces back to these roots (Figures 17-18).

More interestingly, a number of ideas appear to have had their origins in the first sessions of 'playing' with slotting and folded card. The card itself suggested possibilities and the students were quite uninhibited in pursuing their ideas in this 'throw-away' medium. The emphasis on experiment and inventiveness was effective. The group sessions in which everyone shared ideas and discussed the pros and cons of particular structures served to create a large pool of different ideas. As already noted, what the teachers said at this point in the project was of critical importance. By picking out and commenting favourably on the more unusual and exploratory sketch models, they were able to set the tone for the

Figure 17.





Figures 18, 19 and 20.

project and demonstrate that risk-taking was to be valued. This came through in a number of the finished designs (Figures 19-22).

Against this, however, the students remained cautious about risk taking. In the structured interviews the majority said that their advice to other students would be 'to keep it simple'; 'be sure it is easy to make'. Even where students had clearly enjoyed the challenge of resolving problems of construction and making, they still argued against too much originality and experiment. The visitors from IKEA congratulated the students on the variety of their designs and specifically noted their success in overcoming problems inherent in using routing and MDF. This gave the students great satisfaction and clearly added to their self-esteem but did not appear to change their attitude to risk.

Further discussion with the students revealed the motives behind the reluctance to take risks. They were very concerned to obtain good grades and believed that risk taking might prejudice this. They felt the pressure of time keenly and were very concerned that anything too challenging might not be able to be completed. They were 'outcome orientated' and saw a 'good product' as being what teachers (and researchers) would 'really value'.

At the conclusion of the project, the researchers analysed the questionnaires in detail, discussed the classroom notes and reviewed all the material in the students' folders. The photographic record was important in linking the 3-D work to the other material. The researchers believe that the pilot has been effective in helping them to clarify the issues involved in using 3-D sketch modelling in design and technology teaching and learning. The emerging research questions are set out in Table 6.

By their nature these research questions can only be effectively addressed through the medium of action research. They lend themselves to the classic methods used in many curriculum development projects. The pilot showed how much could be achieved by intervening in the work of a class along with the class teacher. In fact, a very great deal could be achieved by class teachers acting as the researchers.

Table 6: The value of 3-D sketch models in the educational design process. Emerging research questions.

- In a sequence of design activity, where can 3-D sketch models be most effectively used?
- What are the feasible alternative sequences?
- What sequence offers the best opportunities for learning and what learning opportunities are particularly dependent on the use of 3-D sketch models?
- How do 3-D sketch models complement other kinds of 3-D models, 2-D models and digital models?
- When are 3-D sketch models unhelpful? What specific aspects of modelling cannot be pursued using 3-D sketch models?
- What are the best materials for pupils to use when 3-D sketch modelling? Are there specific materials that are best in relation to particular production media – for example, clay, textiles, metalwork, food etc.
- How may 3-D sketch modelling be taught at each key stage and is it possible to identify elements of progression and differentiation in students' performance?
- Is it possible to identify more precisely the potential of 3-D sketch modelling in encouraging inventiveness, risk taking and decision-making?
- How many 3-D sketch models can be used in teacher/student discussions and in the student's self-assessment and self-management of the learning process?
- What is the best way to assess 3-D sketch models and what role have they in longer-term record keeping and grading?
- What materials might help teachers and students to make more effective use of 3-D sketch modelling? A kit of parts for direct use by pupils? A publication? A CD or a web site?

Conclusions

As with all pilot research projects, it is important that the following conclusions are read with a 'health warning'. This work has only been undertaken in one school, with 18 pupils of one age group, undertaking one project, with a particular teacher, with particular contributions by researchers etc. Also not to be forgotten is the halo effect which the added interest of visiting researchers created. Nevertheless the findings, as well as the research questions generated as a result of the work, are worth listing in the hope that other teachers will wish to undertake this or similar research with some of their pupils using a different project and different media to produce the 3-D sketch model. It is also hoped further funding will be obtained to continue the work at Loughborough University.

Without exception the pupils and the teacher thought the use of 3-D sketch modelling was valuable. Reasons for this, listed above in detail included: it was much easier to visualise the final product, easier to foresee future construction problems, easier to explain their ideas to others, it enabled pupils to overcome limitations in their drawing skills, it helped pupils to come up with improvements, it helped in the evaluation at various stages and it developed their making skills. Pupils enjoyed making their 3-D models and were uninhibited in pursuing their ideas in 'throw-away' medium.

Figure 21.

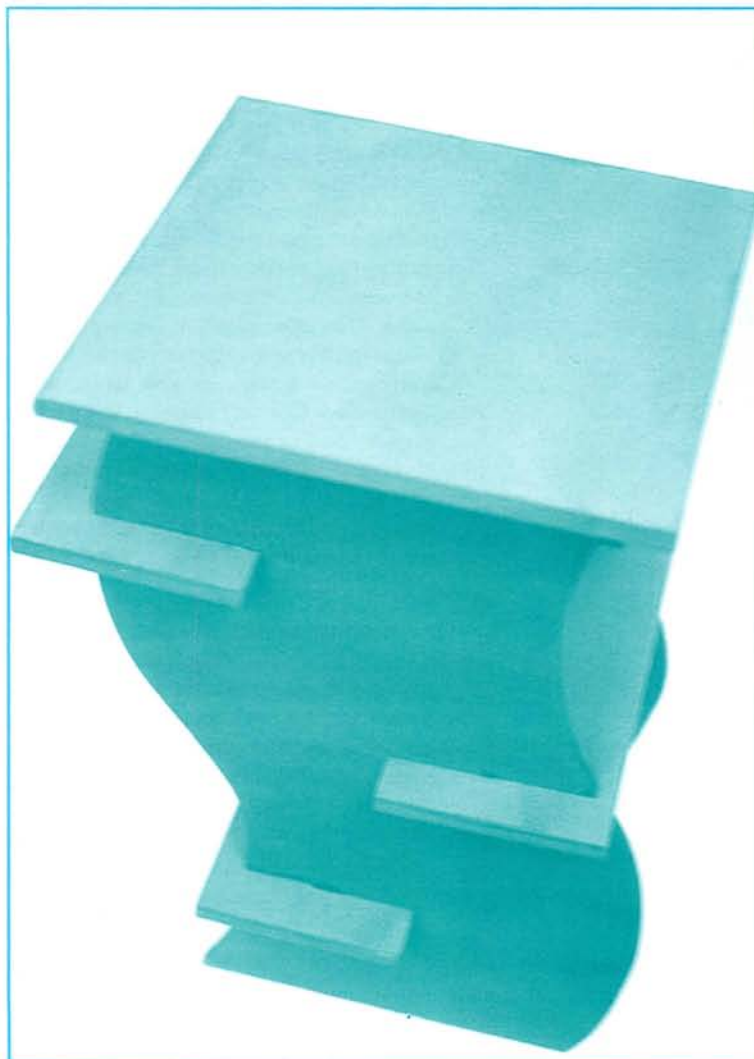
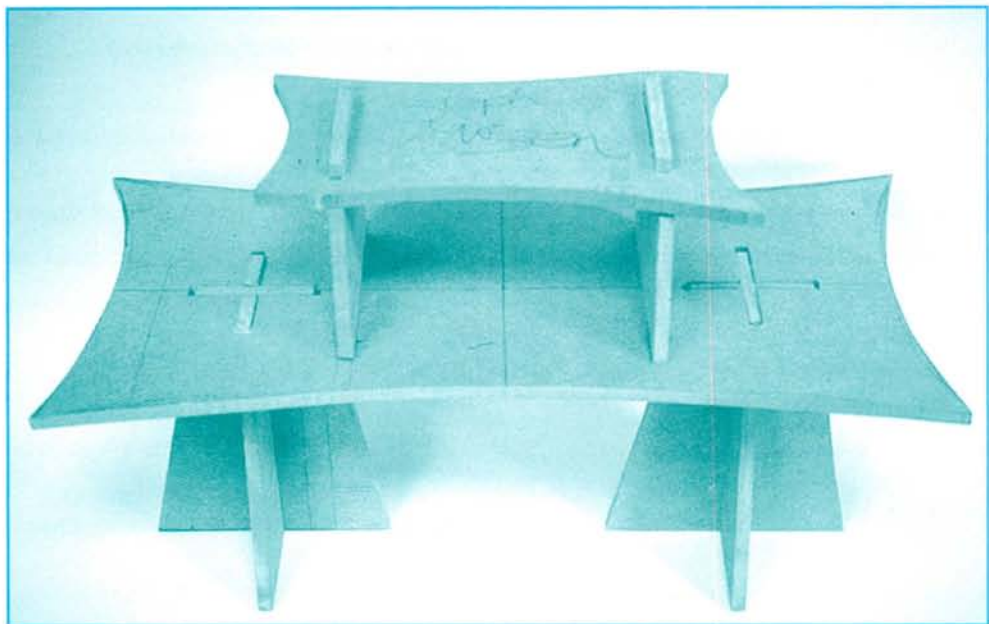


Figure 22.



A key side issue was that of risk taking. The pupils felt it was wise to 'play safe'. They were very concerned about the mark they would receive and clearly there is a need to be explicit about the value of risk taking and innovation in assessment criteria. This is another area for research within design and technology.

The attitude to using 2-D sketching appeared to depend on the drawing ability of the pupils. 2-D sketching for industrial or product design (resistant materials) can be different from sketching used in other areas. Innovative ideas tend to come from the ambiguity in the sketches. How many pupils is this explained to? New work is now beginning by the Department in co-operation with the Loughborough University School of Art and Design (LUSAD), and Gallery of the Future to investigate the uses of drawing as a modelling tool as well as a medium for expression. This is part of Drawing Power, a national campaign for drawing, which has the backing of NESTA.

This pilot helps to show how little is known about the role of modelling in teaching and learning of designing but it is hoped it will stimulate teachers into research themselves. The authors would be pleased to hear from any teachers wishing to do so.

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Web: www.lboro.ac.uk/departments/cd