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# Teaching sketching and its effect on the solutions produced by novice designers

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## Abstract

*Previous research by the authors showed that novice designers do not use sketching as a way to explore and communicate a design proposal, but move immediately to three-dimensional modelling. Neither do they generate multiple solutions. Furthermore, they lack the skills to readily explore their ideas and communicate them to others.*

*The follow-up study described here addressed the questions: How can two-dimensional modelling be taught to students so they are better able to express their ideas? What is the relationship between the ability of a student to make two-dimensional models and the quality of design proposals? What specific skills, knowledge and materials are required for both teaching and learning sketching?*

*Sixteen Year 7 students were divided into eight single-sex dyads. Four received instruction in freehand sketching. Four received no instruction and acted as a control group. The eight dyads were videotaped while producing a solution to a common design brief. Analysis of the data has provided insights into the effects of instruction on the proposals produced by students, as well as feedback on the efficacy of a set of materials for teaching sketching.*

Keywords: designing, modelling, protocol analysis, sketching

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## Introduction

This paper reports the results of a study designed to investigate the effect of instruction in freehand sketching on the ability of novice designers to produce a solution to a design-and-make task. Previous research (Welch, 1996, 1998) showed that novice designers do not use sketching as a way to explore and communicate a design proposal, but move immediately to three-dimensional modelling. Neither do they generate multiple solutions in order to choose and further develop the one with the most promise. Furthermore, novice designers lack the requisite modelling skills to explore their ideas and to communicate them to others. These results have important implications for the teaching and learning of modelling as a central activity in designing and making.

The follow-up study described here addressed the questions: How can two-dimensional modelling be taught to Year 7 students so they are better able to express their ideas and

organise their thoughts? Is there a relationship between the ability of a student to sketch and the quality of design proposals produced? What specific skills, knowledge and materials are required for both teaching and learning sketching?

This paper begins with a review of the literature describing the role of sketching in designing and making. Next, the method used to teach sketching to Year 7 students and to collect and analyse data is outlined. This is followed by discussion of the impact of this instruction on the students' design proposals. The implications of these findings for the teaching of sketching complete the paper.

## Thinking on Paper

Sketching is a form of thinking and the fundamental language of design, characteristics which make it central to students' success in design and technology. Tipping (1983) has suggested that fluent sketching ability may be "the single most

important factor in developing any general design ability" (p. 45) Archer (1979) refers to drawing "as a fundamental component of the wider language of modelling, which in turn is the essential language of design" (p. 133).

According to Olszewski (1981) the idea that sketching is a form of thinking first appeared when the old Italian name *pensieri*, meaning "thoughts", was given to sketches in the art and design world of the Renaissance. Brett (1986) views sketching as "an activity fundamental to human action.... Along with counting and speaking [it is] a primary form of cognition" (p. 59). Temple (1994) has described sketches as "thoughts in action" (p. 323) and Kafai (1995) describes sketches as "objects-to-think-with" (p. 10).

Sketching is essential for communicating ideas, both with "self" and others (Lowe, 1993; Robbins, 1997; Temple, 1994). As Robbins (1997) points out sketching has both a monologic and dialogic function: "Earliest sketches, with their fits and starts, the changes they confront and record, and the questions they raise represent both an interior dialogue that has taken place within the designer and, often, an exterior dialogue with others concerned with the drawings" (p. 35).

Sketching is a complex task (Schenk, 1997) that permeates designing from start to finish and is used for a variety of purposes. First, in the early stages of designing, sketching may help to explicate needs, define and clarify the task. Sketching is a crucial part of the process of understanding a design problem.

Second, sketching allows and encourages the designer to "play" with ideas, an essential stage to creative idea development (Garner, 1994). Sketching is a powerful tool for formalising, exploring and testing these playful musings. Unlike the time-consuming and more costly experimenting with three-dimensional materials and models, designing with pencil and paper provides greater room for experimentation.

Third, sketching facilitates the evaluation of a design proposal and the identification and restating of problems. Sketching provides a

means of testing concepts (Temple, 1994), which in turn will encourage the further generation of ideas (Garner, 1994). Evaluation permits progress "from an innovative mental image to a vehicle for analysis and criticism" (Temple, 1994, p. 24).

Fourth, because sketching is a language it facilitates rapid communication both with the "self" and others. Sketches serve to direct, order, clarify and record ideas that come out of this conversation. Sketches record the ongoing conversation with self as thought is externalised and developed into design solutions. Such conversations, according to Garner (1994), "may involve asking the right questions, constructing the right structures and providing conjecture" (p. 68). Additionally, the externalisation of visual thinking as sketches allows people other than the designer to participate in the development of a proposal.

All children enjoy and have the capability for sketching simple stick figures or outlines of shapes. Activity with crayons and paints is pleasurable to most children. Sketching experiences are an integral part of most curricula. Why is it then so difficult to persuade design and technology students to sketch ideas before they start to make things? Is it because they lack the requisite skills? The next section of this paper describes an intervention study in which the effects of teaching freehand sketching on the strategies used and the design proposals produced by novice designers was investigated.

## Method

Two Year 7 classes participated in the study. All students in Class A were given instruction in freehand isometric sketching. This instruction, given by the regular classroom teacher after in-service training, was part of a 25-hour unit of work focusing on structures. Students in Class B did not complete the unit, received no instruction in sketching, hence served as a control group. Following completion of the structures unit eight students from each class were selected and divided into single-sex dyads. The eight dyads were each given the following context and

### Designing a toy or game for a friend in hospital

The nine items below will help you begin thinking about designing a toy or game for a bedridden friend. Try to answer all nine before you begin developing a solution.

1. What type of toys do you and your friends play with?
2. What type of games do you and your friends play?
3. List some toys or games that require hand and eye co-ordination.
4. List some toys and games that require a lot of thinking.
5. List some toys and games that can be played alone.
6. List some toys and games that you play with one or more friends.
7. List some educational toys and games.
8. What safety issues are important?
9. How often will the toy or game be used? For how long?

Figure 1 The contextualising items

design brief:

*The Situation:* Your best friend has had an accident. While not seriously hurt he/she is confined to bed in the hospital for two weeks. Not able to move very much, and able to use only a bed tray as a play surface, your friend has told you they are becoming bored and wish they had a new toy or game to play with. You have decided that when you visit next time you will take a toy or game you have designed and made. You now have to make some decisions.

*The Design brief:* Design and make a toy or game that will amuse and intrigue a bedridden hospital patient aged approximately 12 years and that can be played with on a bed tray.

After reading the context and brief students were instructed to complete a worksheet (Figure 1) containing a set of contextualising items before starting to design and make. Students were given two hours in which to complete the task. Their designing and making was video and audiotaped. The natural talk between the subjects was transcribed verbatim and the transcripts were segmented into speech bursts. A description of the subjects' actions was added to the right of each segment. The time at which a change in the subjects' actions occurred was added to the left of each segment, thus allowing

calculation of the duration of each period of action.

A coding scheme (see Welch, 1998) was used to code actions of the subjects. The natural talk while designing and making informed the coding. Those actions coded as designing were analysed using descriptive statistics. This analysis provided data for "mapping", using an XY scattergraph, the design strategy of each dyad. These maps provided a visual representation of the design process used by each dyad, which in turn permitted a comparison both between dyads and between the two groups of dyads. (For a more complete description of this method see Welch, 1996, 1998.) Analysis provided insights into the effects of instruction on the proposals produced by students, as well as feedback on the efficacy of a set of instructional strategies for teaching freehand sketching.

### Results

Figure 2 shows the strategy used by Dyad 8 and is representative of the four dyads who received instruction in sketching. Figure 3 shows the strategy used by Dyad 1 and is representative of the four dyads from the control group. Both maps show clearly the small amount of time devoted to sketching.

However, six of the eight dyads appeared to recognise that sketching precedes modelling

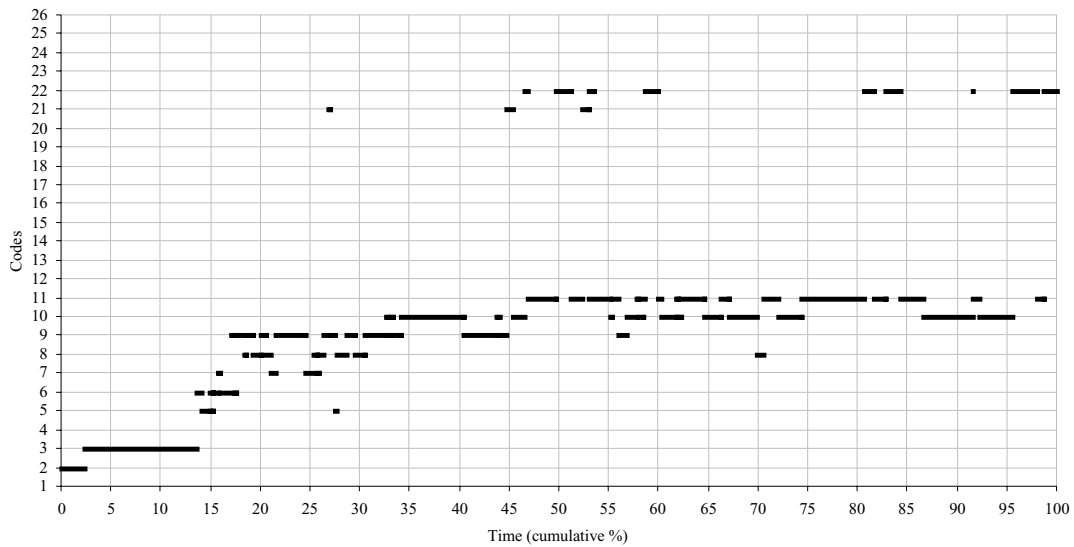


Figure 2 Strategy used by Dyad 8

and making with three-dimensional materials. For example, S16 picks up a piece of paper and a pencil and says to his partner "Why don't we make a rough sketch of what we're going to do?" His partner responds "Yeah, paper. That's like our ... going to be like first and then we'll do it" (lines 446-450).

as making was in progress, providing a written record of making as it occurred rather than a plan for future action. The other two dyads who made a board game made no attempt at sketching. Dyad 3 (Class A), who made a toy that involved dropping a marble down a columnar maze, carefully divided a sheet of paper into four equal parts. In the top left section the student sketched a side view of the maze. In the top right section he sketched a top view and in the bottom left section a "bottom" view. Dyad 2 (Class A) and Dyad 4 (Class B) each sketched a side view of a marble maze, but once completed (in just a few seconds) never again referred to the drawing.

Of the six dyads who made some attempt at sketching a proposal three were in the control group. Of the four dyads (1 in Class A and 3 in Class B) who made a board game two (both in Class B) sketched very detailed plan views. However, these were not drawn prior to making the game, but rather were developed

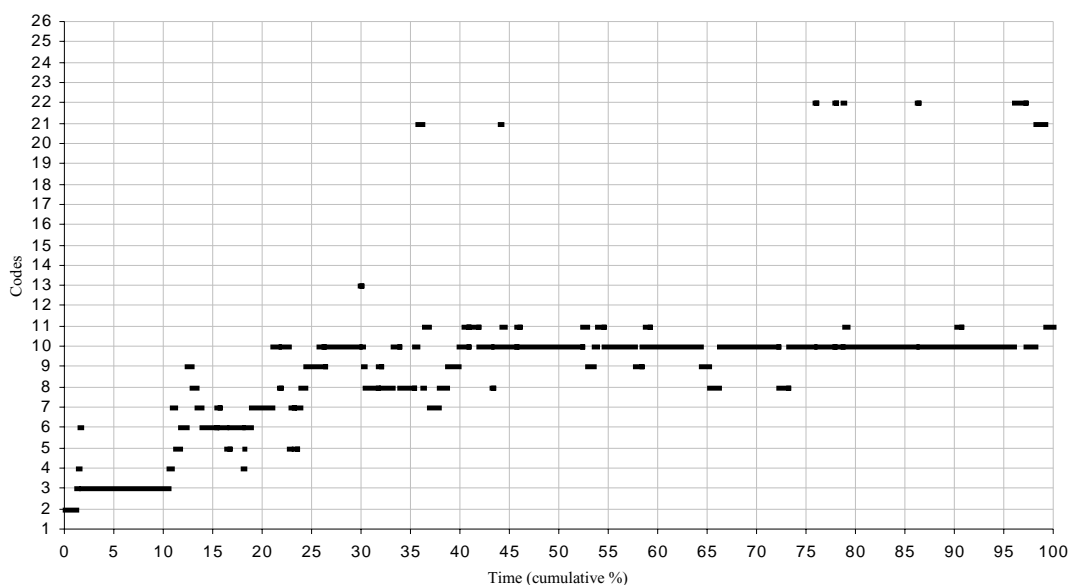


Figure 3 Strategy used by Dyad 1

Dyad 8 (Class A) made the most accurate sketch of what they proposed, but even so spent very little time on this.

The maps also show the dominance of three-dimensional modelling, a result consistent with that from two previous studies by the author (Welch, 1996, 1998). The maps show how, once the students had completed the contextualising items, they moved quickly to modelling using three-dimensional materials. The students were almost constantly manipulating materials as they explored elements of a proposal. They did not, on any occasion, return to drawing as a way to explore modifications to their original solution. They generated new ideas by manipulating three-dimensional materials, not by sketching.

**The contextualising items**

The contextualising items appeared to play a significant part in the development of a solution for all eight dyads. While responding, the students interspersed their conversation with discussion of the performance criteria contained in the context: the person is confined to hospital, cannot get out of bed and the only flat surface available is a bed tray. For example, when S15 and S16 are responding to "List some toys or games that require hand and eye co-ordination" the following conversation occurs:

S16: Like hockey 179  
 S15: You can't play that in bed 180

When S1 and S2 are reviewing their answers to the items S1 notes that S2 has written the word "never" on the answer sheet. This prompts the following exchange:

S1: Never. What's that? 435  
 S2: Never ending games. 437  
 S1: Never ending games? Why would you 450  
 have never ending games? 451  
 S2: Because you don't know how long he's 453  
 going to be in there, and you don't want 454  
 him to run out of ideas. 455

The contextualising items also stimulated discussion of solutions and appeared to

provide a supportive way for subjects to develop their ideas. Simultaneously discussing and manipulating materials was also a preferred strategy of subjects. The data suggests that this is an important strategy for students as they attempt to clarify, explore and communicate their ideas. In other words, it appears that it is not appropriate to require students to only think about or sketch solutions.

**Discussion**

Analysis of the way in which subjects in this study generated possible solutions has made evident four characteristic behaviours: (a) their previous knowledge is drawn on in order to generate solutions; (b) sketching is not a method by which subjects explore solutions; (c) discussion between subjects plays a major role in the clarification of ideas; and (d) subjects rely heavily on simultaneously discussing a solution while manipulating materials.

According to Hayes (1989), "it is a very rare event for a person to solve a problem without making some use of their own knowledge of ... the world" (p. 51). There is evidence from this study to support the findings of Kimbell, Stables, and Green (1995) that when subjects are generating solutions "previous knowledge is drawn on and developed in new contexts" (p. 34). For example, while responding to the contextualising item "List some toys and games that require hand and eye co-ordination", the students in Dyad 8 had discussed a "ball and cup" toy. The conversation went as follows:

S16:... there's this game 195  
 where you hit it off the  
 thing and 196  
 you try to get it into a cup.  
 It's like, 197  
 I forget the name of it, but  
 its like 198  
 you have this thing, its  
 like a handle 199  
 and there's a ball ... 200  
 yeah, you try to get it in ... 201  
 S15:Don't know what its called. 202  
 S16:Just put ball and cup. 203

Most design process models contained in the technology education literature include a step during which the student must sketch several design proposals from which they can select the most promising. Figures 2 and 3 illustrate how little time subjects in this study devoted to generating a single proposal by sketching prior to three-dimensional modelling a solution. Several dyads did make perfunctory attempts at sketching a solution, but these were quickly discarded in favour of exploring possible solutions by manipulating materials. Equally evident from the data is that subjects did not generate a range of possible solutions from which they could choose the one with the most potential. In all cases subjects proposed and developed one solution. A small number of empirical studies have provided evidence that this strategy is also true of expert designers (Darke, 1979; Eastman, 1970).

The data show that students need little encouragement to talk about their ideas. It is important to permit this, for as the Department for Education in the UK suggests "by talking about the quality of their own work and the work of others children learn to evaluate" (Department for Education, nd, no page). This approach is supported by Schön (1987) who wrote "drawing and talking are parallel ways of designing and together make up ... the language of designing" (p. 45).

### Conclusion

Throughout designing and making sketching is used for a variety of purposes. Initially, sketches may help to explicate needs, define and clarify the task. Later they are used when exploring ideas, evaluating proposals, identifying design problems and communicating with others. Sketching may also encourage the development of a general design ability.

The study reported here has shown how, when left to their own devices, Year 7 novice designers, whether taught sketching skills or not, do not use it as a way to develop a proposal. Rather, students explore their mental images using three-dimensional

materials. Subjects in this and earlier studies did not view sketching as a mediating instrument between mind and hand. Yet if students are to develop capability in designing and making they must learn the relationship between sketching and thinking, and how to use sketches to clarify and show details of their design thinking.

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