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Design and technology as revelation and ritual

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Abstract

This paper reports one of several case studies of Key Stage 3 pupils involved in designing and making. It explores how a teacher structures tasks, and the impact that has on the pupils' experience of the design process. Although the teacher uses the usual steps in the design process (defining a context, and creating a design brief and specification etc.), this is done in a ritualistic way such that pupils are not made aware of it. Further, in order to control the complexity of the task, the teacher reveals constraints on, and features of, the design, which create problems for the pupils. The explanation for such an approach by the teacher is found in the teacher's view of the design process and in his aims for the particular activity.

Introduction

We have observed four projects typically lasting 6-12 weeks involving designing and making: (a) a kite (our pilot study); (b) a badge which had an associated electronic circuit (the subject of this paper); (c) a mobile; (d) a moisture sensor employing an electronic circuit. Our intensive study of the projects tries to capture the range of activity for selected 'target' pupils, as well as collecting evidence of their perceptions, and those of the teacher, concerning what they think they are doing.²

The research data presented in this paper is based upon the first of the full case studies, that of the design of a badge face and the making of an electronic badge (one that used a light-dependent resistor (LDR; as *input*) to light two light emitting diodes (LED's; as *output*), activated by a transistor (the *process*)). We followed three boys, referred to as B, D and T. The issues arising in this case study do, however, emerge in other studies.

The context

In design and make projects that require complex knowledge and new types of skills, such as those involving electronic circuits, it is understandable that a teacher will control the task carefully to ensure that pupils can use existing knowledge and skills to progress and achieve a working circuit. The teacher in our study had three major objectives: to teach the pupils control concepts (input, process and output), to understand how simple electronics circuits behave, and how to construct such a circuit from a printed circuit board (PCB). *Designing* electronic circuits is too demanding for most Year 8 pupils, although they can develop the concept of control by *choosing* a variety of *inputs or outputs* to go with the process element of a transistor as a switch using a given circuit (however, they need to understand how to modify the circuit to accommodate the different inputs and outputs). To ensure such understanding, it is necessary to introduce the details of the circuit gradually, and to allow pupils opportunities to handle components

and circuits.

In our previous work we have shown how a teacher uses the design process to structure the progress of a project, and in doing so *reveals the process* to pupils (McCormick, Hennessy & Murphy, 1993; McCormick, Murphy & Hennessy, 1994). Pupils were not made aware that they were involved in a process, and hence had less opportunity to learn how to employ such processes. The teacher's way of structuring the task for the electronics project emphasised a linear design process, one dominated by 'making', as Table 1 shows. As we shall show, this approach has important consequences for the

Week & Session	Major Task	Design Process
1:1	Copy out 'Situation'	State Needs
	Decide 'Design Brief'	
	Discuss 'Considerations'	Specification
<i>Homework</i>	Draw four cartoon faces	Initial Ideas
1:2	Draw four faces in 70 x 70 mm square	Initial Ideas
2:1	Draw face in 140 x 140 mm square with eye and nose hole dimensions [Choose colour of acrylic backing sheet]	Final idea/Modelling Planning the making
2:2	Draw face on 70 x 70 square card	Making
	Stick card face onto acrylic	Making
3:1	Drilling holes in face	Making
<i>Homework</i>	Find out prices people will pay for badge	Research
3:2	Draw PCB layout and components	Knowledge input/check
	Calculate average price of badge	Research
4:1	Complete a work sheet on circuit	Knowledge input/check
	List examples of electrical and electronic equipment	Knowledge input/check
4:2	Solder components	Making
5:2	Solder components	Making
	Cut acrylic for back cover of PCB	Making
6:1	Answer given evaluation questions	Evaluation
	Finish soldering and sticking acrylic on back of badge	Making
6:2	Cost the badge	
	Work out labour charge, all badge price and profit	
	Finish soldering etc.	Making

Table 1: the teacher's task structure for the electronic badge project pupils' view of the design process and for the progress of their project.

Ritual of 'the design process'

The teacher began the project with the 'Situation' being presented:

A theme park has opened in [place] and it wants to advertise itself. It plans to sell cheap lapel badge based on cartoon characters in the park. To make these badges more interesting, a basic electronic circuit will make something happen on the badge.

This was to be copied by the pupils and it was set within the general title of 'Festivals', but the links to the 'Situation' were not discussed, and from then on no further reference was made to festivals. The teacher continued in the session by asking the pupils to define the 'Design brief' and draw up a spider diagram of 'Considerations' (specification), tasks which all the pupils seemed familiar with. He did not, however, elaborate on the 'Situation' or the 'Design brief', nor invite pupils to discuss them in the context of the planned project.

The three target pupils' design briefs include some interesting differences that illustrate how the 'Situation' is being interpreted by them. B & T interpreted it as a "button is pressed to light up the eyes", whereas D makes no such inference, but says "to design and make a clock badge". The implication of these differing interpretations, and the lack of discussion of potential outcomes, is that the pupils had little ownership of the project. Furthermore, their initial ideas of what their personal 'briefs' linger and influence future tasks. For example, D continues to talk about a "clock face" for several lessons and abandons the idea only when he realises that the electronics will not be like that of a watch. He also imagines that the battery will resemble that in a watch and is almost incredulous when the teacher shows a comparatively large conventional dry 9-volt battery that he (rightly) considers too heavy for a lapel badge.

The pupils' views of what constituted appropriate considerations were pooled and represented in an overall spider diagram, which they used to add to their own. However, this is another example of a ritual as these considerations were never mentioned again, not even in the final evaluation. Indeed new ones are continually added by the teacher without discussion, particularly in relation to the making process. These new ones reflected the constraints imposed by the teacher as he worked out his plan for the project (e.g. the materials to be used, the dimensions of the face, and the eyes and nose positions to fit the circuit). These additional considerations, unrelated to the pupils' original design briefs and design ideas, led to problems for the pupils.

Next the teacher gives several tasks relating to drawing the faces for the badge which implicitly reflect the sub-processes of 'generating ideas', 'developing a chosen idea' and 'planning the making'. However, this is again done in a ritualistic way as the following examples indicate.

At the end of the first session pupils were asked, for homework, to create four cartoon faces as potential designs for the badge. No parameters were given other than that all four should fit into the design sheet and that pupils should be 'creative'. As with the 'Situation', 'Design brief' and 'Considerations', this step of producing four designs appeared to be a standard one and, again, was accepted without question by the pupils. However, in the next session pupils are asked to re-draw the faces so that they touch the sides of a fixed drawn square (70x70 mm). The reason for this was not made clear until a later session (2:2). Evidence from the pupils' folders indicates that pupils had to modify their designs in order to fit these new demands. For example, B had originally drawn a thin 'carrot' character, which he had to distort to make it fat enough for it to touch the sides of the square.

It was not revealed that the 70x70 mm square was a significant fixed aspect of the badge design (of the status of a 'consideration') i.e. the size and shape of the planned badge. The fact that the creation of several designs is perceived by pupils to be a ritual, is seen in D's comments to the teacher implying he has already made a final choice while he is still completing the four drawings. This, along with pupils' acceptance of apparently irrelevant tasks, testifies to the 'veneer of accomplishment' that such an approach provides.³

After completing this second set of drawings, the pupils are asked to pick one design (as their final design) and then to draw it in a 140x140 mm square, which specified the dimensions of the eyes and nose, introduced and fixed by the teacher at this point. The need to fit these dimensions to the design created earlier (where the eye and nose spacing were not fixed and were a matter of personal design), added to the frustration already felt by pupils because of the requirement to fit the face to the sides of the square. It was never made clear to pupils why they had to do the 140x140 mm version of their face. The teacher appropriately saw it as a 'working drawing', where the dimensions for the holes to be drilled for the circuit parts could be seen by the pupils. The pupils then had to scale down again to fit the teacher's intended size for the badge (i.e. the 70x70 mm specified earlier). (Pupils did not know this at this point.) The scaling operation had the effect of distorting pupil's designed faces either because they used a linear scaling process on some crucial dimensions, or because they effectively re-drew the faces. Neither of these solutions was satisfactory in terms of a design process which was supposed to allow pupils to try out ideas (for homework), work them out (in session 1:2), and select the best one (in sessions 2:1 & 2:2).

The pupils were following the tightly formed task structure without question, working out the

teacher’s intentions, and conforming to the usual culture of the classroom as created by the teacher. Thus when there appeared to be little logic in the process, such as going from an original design to a 70x70 mm design to a 140x140 mm diagram with dimensions, and back to a 70x70 mm final design with dimensions, they did not seem perturbed or alienated from the task, even when it caused them scaling problems, which they had to tackle without support, and when the design (the one thing they had ownership of) was adversely affected.

Revelation of the constraints and features of the badge

The teacher used the idea of ‘revelation’ in a different way to that which we have reported in a previous case study (McCormick, Hennessy and Murphy, 1993). We have already noted that the teacher introduced a condition of the badge face having to touch the side of the 70x70mm square, an apparently arbitrary element in the specification. In fact he was looking ahead to the task (not yet revealed to the pupils), that they would have to mount the face (drawn on card) onto a coloured square of acrylic, and hence the face should fill as much of the square as possible (to avoid the background colour dominating the badge). He could well have used his intended task in a different way by explicitly including limitations as part of the ‘Considerations’ (specification), or discussed at the beginning the way he intended the badge would be constructed. This revelation of constraints was not an isolated incident, but one which occurred continually throughout the project, as Table 2 indicates. (By

session 2:1 the pupils have ‘finalised’ their face design, and at which point the teacher introduced the dimensions of the eyes and nose - see Table 1 for the sequence of tasks.)

So, it is late in the project when the teacher revealed the nature of the circuit and the fact that the LED’s and LDR have relatively fixed positions. Pupils had to continually adjust their face designs in response to the emerging problems created by the teacher’s design constraints. For D this, in the event, involved him in some useful problem solving to get the light to come from the defined holes (see Figure 1, point A) to where he wants the eye pupils to be (Figure 1, point B). But in the end he did not succeed in solving the problem to his satisfaction, and this affected adversely his view of the project, but not of design and technology generally.

Explanations of teacher behaviour

The teacher deliberately did not emphasise the design process; it was not one of his main aims, and he seemed to view it as a logical approach rather than as a process which involved sub-processes that had to be taught and learnt:

“although I’d like them to understand and use the design process and I think it’s quite a nice framework for them to fit things on to, I don’t think there’s a great need to be dogmatic about it and say you must learn it...the nature of projects leads them through the design process despite the teacher’s bit, going through it with them in front of the class...”

He appeared to see the ‘logical approach’ as a ‘way

Week & Session	Incident, Decision or problem	Comment
1:1	Situation: badge for new theme park electronic circuit that will make something happen.	No discussion of this, nor link to the theme of Festivals
1:2	Size of face (70 x 70 mm) (indirect) Face must touch each side of face.	This constraint went unnoticed by pupils
2:1	Eye spacing defined (through the acrylic backing sheet dimensions given in the 140 x 140 mm diagram). Colour of face on card compared with colour of acrylic backing sheet. Printed Circuit Board (PCB) shown for the first time. Battery shown for the first time. Use of pin to attach to clothing.	D has difficulty matching his eye spacing to the requirements laid down in backing sheet dimensions (see Figure 1). D chooses the wrong colour and teacher corrects. Only shown to D. No explanation of relationship to the face is made by teacher. Revealed to some of the groups. D thinks it is too heavy, and teacher suggests a strong pin.
2:2	Face on card 70 x 70 mm, must touch sides, and it must ‘cover’ the backing sheet. Card to be stuck onto the acrylic baking sheet.	First direct definition of face size. This shows for the first time the direct comparison of the face layout and the template for the requirements of the circuit. T shows he has a problem with the patch over the eye (see Figure 2). B also has a problem and makes adjustments.
3:1	LDR (the ‘nose’) can be drilled in a different place.	Teacher says this in passing when he is introducing the drilling operation. T tries to shift his (nose - LDR) hole over as he drills to prevent it intruding into the patch over the eye.
4:2	Positioning of LED on PCB can be adjusted to suit eye spacing on the face.	Teacher makes the link of the PCB and the face for the first time.
5:2	There will be a back cover for the PCB.	

Table 2: critical incidents in the electronic badge project for ‘revealed’ constraints and features

Figure 1: D has to solve the problem of getting the light from A to B

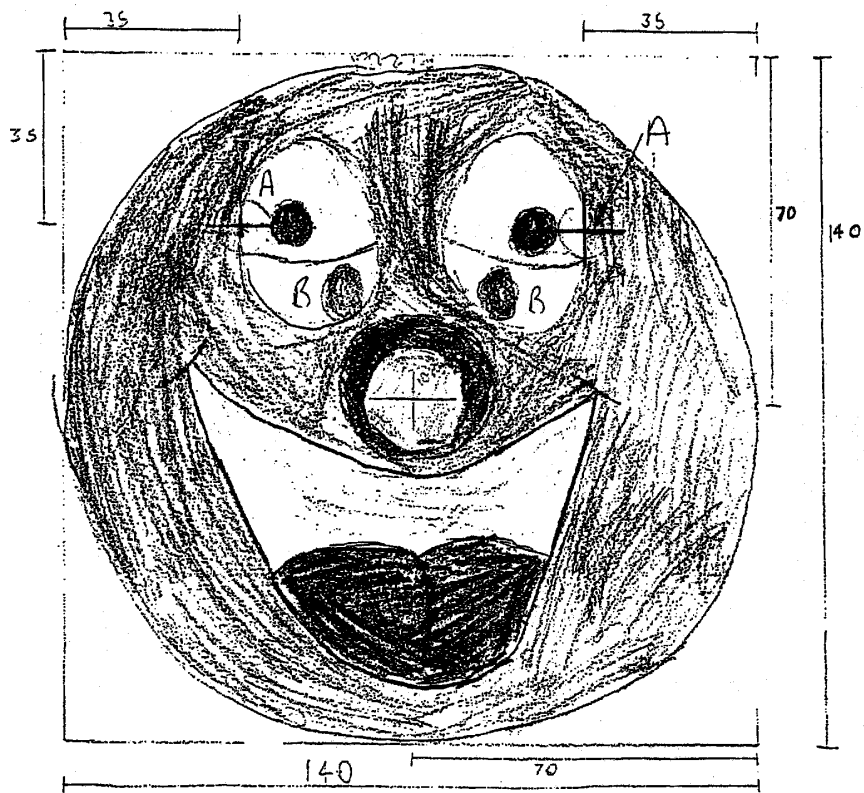
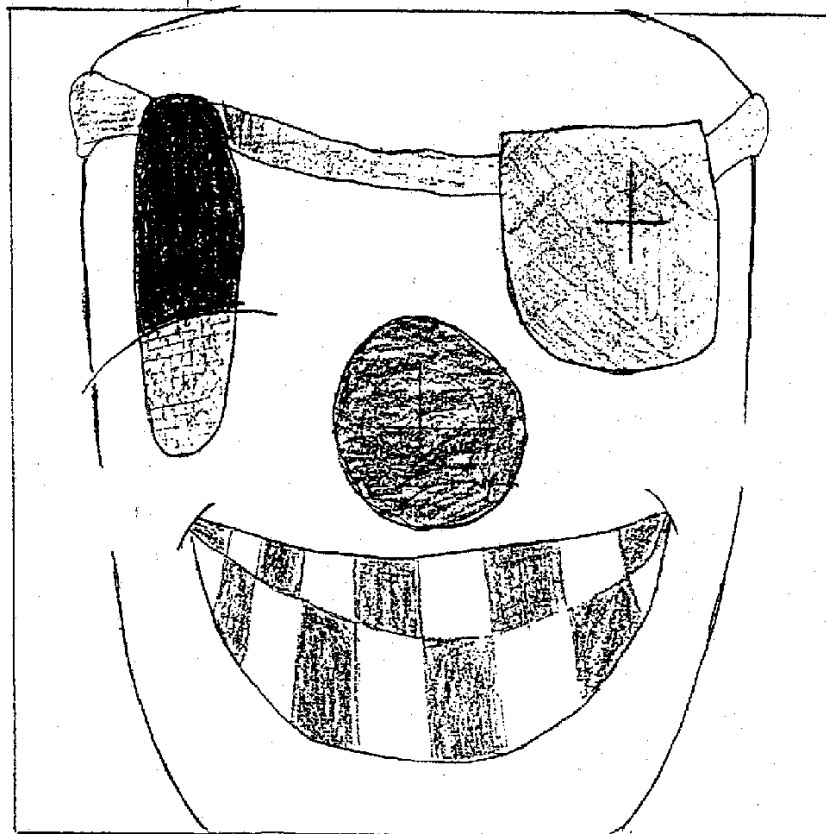


Figure 2: T's problem of the teacher-defined eye spacing conflicting with his eye patch



of working', and in that sense the sub-processes were of little significance to him. For him the design process was very much in the background, not just in this project but in general: "I'm relying rather a lot on a subconscious level of going through things. Some of them won't do it, some will." Because he appears not to have any sympathy with the design process as a series of inter-related sub-processes, there is little likelihood that he would teach it as procedural knowledge with some intellectual basis. Although he saw the 'Situation', 'Design brief' and 'Considerations' as common starting points for projects in all areas of design and technology, they were merely steps that organised the project, much as was true for science teachers who followed the routine of 'hypothesis, method, results, and conclusions'. He was aware of the lack of emphasis he gave to the 'Situation', 'Design brief' and 'Considerations', which reflected his particular agenda for the project and for the subject generally. The teacher constantly stressed knowledge and skills when discussing the aims of the project in interviews before the project started and after it had finished, and his structuring of the task reflected this (see Table 1). He was keen that pupils should have made something that they enjoyed and that they wanted to take home, and he recognised that he had not used some of the design processes meaningfully:

"so maybe they haven't seen the connection between the design brief and the badge.... I don't see ... much use in banging away [at the brief] if they're happy with the end result, they've made a badge that eyes light up and they understand why it's lighting up and how it's lighting up."

This quote encapsulates all his agenda for the project; knowledge, skills and a product outcome. The focus on an individual product, successfully working, is probably a common one for many former CDT teachers.⁴ This agenda is appropriate, based on what pupils want from this area of the curriculum (a working product), and on the complexities of dealing with electronics projects. Where projects require understanding, as is found in electronics, it is impossible to initially make clear to pupils all the design decisions, and so teachers have to reveal them as they develop the project.

If we are concerned to see designing as an intellectual process, then it is important that the task structure, and the supporting teaching interventions, are such that pupils are made aware of the processes involved. However, as we have indicated this requires some teachers to undertake a different view of the activity they are involved in, something that will not be easy.

Indeed there are legitimate disagreements among teachers, that means that differences of perceptions and hence teaching will remain, with consequent 'mixed messages' being experienced by pupils.

References

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Notes

- 1 We would like to acknowledge the work of Sara Hennessy in collecting and analysing data for the research reported here.
- 2 Our research will result in six detailed case studies, building upon an initial pilot, as part of the project *Problem Solving in Technology Education: a case of situated learning?* funded by the UK Economic and Social Research Council (grant number R00023445). The 'kite project' was briefly reported at IDATER 93 (McCormick, Hennessy & Murphy, 1993), and a fuller version in McCormick, Murphy and Hennessy (1994). These publications also give a fuller account of our research questions and methods.
- 3 See Hennessy, McCormick and Murphy (1993) for a discussion of this concept of 'vener of accomplishment'.
- 4 In an earlier quote he used the term CDT (Craft, Design and Technology) to describe what he did, and this was a common reference in his interviews. As a head of department for CDT, which forms one of the subjects of 'design and technology' as a cluster (a new subject), he still feels a strong identity with this subject.