Developing an effective pedagogy in the classroom: implications for design and technology

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Abstract

The nature of creative problem solving is summarised and used to examine examples of teachers' practice. Examples are drawn from both the 'design and make' approach and the Young Foresight initiative. Characteristics of the teachers' pedagogy are identified and linked to the nature of the activities and tasks that the students were engaged in. Effective practice resulting in creative problem solving is identified and the influence of task and pedagogy on this practice discussed. Questions are raised about how insights provided by the Young Foresight initiative can be used to enhance problem solving in the curriculum as a whole.

Keywords

design, technology, problem solving, creativity, pedagogy, young foresight

Introduction

Supporting and developing creative problem-solving, is central to the rationale of the design and technology curriculum, but is less emphasised in implementations that give more attention to developing design and make skills and teaching the conceptual knowledge required for GCSE examinations. A recent initiative in curriculum development, the Young Foresight Programme, has deliberately set out foster creativity and innovative thinking.

Background

We hold the view that knowledge is situated and take a social constructivist position on learning, and have developed the arguments for this more fully elsewhere. (Murphy and McCormick, 1997) In summary, this perspective leads us to suggest the following conditions for creative problem solving:

- students are engaged in activities which are authentic, i.e. relate both to the actions of design in the real world and are personally meaningful
- the problems are dilemmas that the students perceive, they cannot be given
- the students are active, reflective, purposeful and knowledgeable: the knowledge that they use integrates both procedural and conceptual knowledge
- students draw on social resources that develop as they collaborate with each other and the teacher to achieve common goals.

In considering the creativity embodied in problem-solving design and technology activities, we are concerned as much with the processes as the products. The definition of creativity on which we draw is that of Amabile (1990). She suggests that a product or response will be judged to be creative to the extent that it is both novel and appropriate, useful, correct or valuable in the context of the task in hand. She sees creativity being expressed in situations where domain-relevant skills, creativity-relevant skills and task motivation are interacting.

We would suggest that within the framework for problem-solving outlined above, domain-relevant skills will include the procedural and conceptual knowledge that the student can draw on, creativity-relevant skills will be embodied in both the student's ability to be reflective and the insights developed through collaboration. Task motivation will be supported by the use of authentic activities.

Thus the pedagogy that we would expect to provide opportunities for creative problem solving, will support the students by providing situations and teaching which meet the criteria outlined above.

The case studies
We have drawn on two research projects for our analysis: the first was reported in *Problem-solving in Technology Education: A Case of Situated Cognition?* (McCormick *et al*, 1996) From this we consider the actions of two teachers, Martin and Roger, teaching Year 8 and Year 7 classes respectively. These cases are described in detail elsewhere. (Murphy *et al*, 1995)

For his Year 8 class, Martin had chosen the task of making a moisture sensor. The task had two parts, assembling the circuit, and designing and making a box to contain the circuit from sheet styrene. Martin was committed to the design process as a problem solving process and was keen that the students should be creative, 'it is absolutely essential that they learn to design in a creatively developmental way and that they can take an aspect of their design, then take a piece from somewhere else and add them together and come up with a design that they are then happy with ... and then they are critical of it ... that is the only way design develops'.

There was evidence, particularly while the students were developing their initial ideas, of emergent creativity in their responses. Martin had encouraged the students by saying, 'there is lots of scope for designing, making nice packaging rather than just a square box'. Amy had already decided to make a bath water level detector and a small group of girls shared ideas with her for the box, which linked to this use.

Nancy:	*What about something in the bath? Something to do with water, 'cos it can go in the sink as well as the bath. You could do it in the shape of a soap, you could have it in the shape of a sponge or in the shape of a bubble, the shape of a ... no, not a tap.*
Mary:	*A drop thing*
Nancy:	*Tear drop*
Mary:	*A drop of water.*

As they worked, they shared ideas by sketching and talking. They reflected critically on their ideas, rejecting some on the basis of impracticability. For example, Nancy suggested that Amy might use a toothbrush shape for her box, but they realised the dimensions needed to hold the circuit board would result in an unrealistic shape.

Although there was evidence that the students were able to engage creatively with the task, Martin only had limited success in supporting creative problem solving because:

- His introduction to the task only provided limited conceptual knowledge about use and operation of sensors. The students could only relate the use of the moisture sensor to their own lives and so the authenticity of the task was limited.
- He saw problem solving to be achieved by following the procedural steps of the design process rather than as dealing with the dilemmas emerging as the students worked on the task. As a result he did not recognise the need to support the students to find solutions to such dilemmas for themselves.
- When students met problems with making their designs, it was Martin who became the problem solver because only he had the necessary knowledge. The students lost their autonomy and became instruction-followers.

Roger described problem solving as, 'they can see the need in their mind ... they can then focus their mind on ways of fulfilling that need to solve that problem ... sometimes complicated to make ... but they always come up with ideas; why can't we do this, that and the other. I say, well because we haven't got the facilities here to do that but try and keep it simple … and they are quite good about discussing and bringing their ideas into something realistic. And that's problem solving'. His comments suggested he understood the need to maintain the students' autonomy by providing them with support to reflect critically on their ideas.

The task that Roger used was the making of a charity collecting box with either a mechanical or electronic response. Pupils, Katie and Tania worked together to make a moneybox on which a bird pecked at a tree. This product was judged to be a creative response to the task and they operated as creative problem solvers of most of the dilemmas that they met. For example, they encountered a problem when the mechanism struck the coin collecting box. They demonstrated the problem to Roger:

Roger:	*Why doesn't it* (the woodpecker) *continue to wiggle?*
Katie:	*Because of that* (pointing to the box).
Roger:	*Did you want it to sway a bit more? What about this part of the box?* (pointing to the side nearest the pendulum)
Katie:	*You could cut it away.*
Roger:	*If you wanted that* (the pendulum) *to swing backwards and forwards, would you actually need that part of the box? Is that a possibility?*
Katie:	*You could cut down there and it would be able to go further to the side.*

Roger demonstrated how Katie's solution could be achieved by drawing on the box to suggest how they could reduce the size. However, he couched his suggestion in a way that left the decision to use it with the girls.

The key elements of Roger's pedagogy that enabled him to provide a supportive environment for problem solving were judged to be:

- An effective introduction to the task that included: a discussion of need in the context of charities; the opportunity for the students to share their knowledge of charities; the students' personal experience of commercial collecting boxes; a critical examination of similar boxes made by earlier classes; and discussion and explanation of how the effects were produced.
- Support for conceptual knowledge by provision of model mechanisms and circuit diagrams which students could adapt to their situation.
- A style of interaction with the students that supported their thinking processes but left decision making with them and so maintained their autonomy.

The Young Foresight initiative (Murphy *et al*, 2000, 2001a, 2001b), is an innovation in teaching for creativity aimed at Year 9. The initiative (discussed here in its trial form) provides materials for use with students and guidance to help teachers support and develop students' problem solving and creativity, while meeting the broader aims of the National Curriculum for design and technology. Outcomes are designs for future products produced by teams of students. An additional feature is that Young Foresight encourages the involvement of an industrial mentor to support the students. We use evidence from two teachers, Ken and Jerry, considered to be effective in terms of student engagement, quality of outcome and quality of learning, to show how their pedagogy was successful in producing creative outcomes.

The Young Foresight activity is designed in three phases: Phase 1 addresses conceptual and procedural knowledge, for example learning about sustainability and techniques for generating ideas; in Phase 2 students create scenarios for the future as contexts in which to generate ideas for products and critically evaluate them; in Phase 3 they develop ideas for one product and present these to the whole class. Thus while the teacher sets the contexts for the activities in phase 1, it is the students who generate the tasks for phases 2 and 3 and the role of the teacher becomes one of supporting students' thinking and decision making.

Ken saw Young Foresight as addressing the need for more emphasis on creativity and problem solving in the existing curriculum: 'There is a danger with design and technology that teachers control how creative the youngsters can be ... we are creating a more stereotyped, easier to manage curriculum where the outcomes are more likely to be uniform ... what you don't have is 'stop, let's look at the broad context of technology and its impact on society'.'

Ken's concern to look at the broader context was demonstrated in a phase 3 lesson when he supported students' thinking about the rationale behind their design by prompting them: 'I want to hear words like needs and wants ... who would use it? ... What specific type of person would the user be? ... What would their salary range be? ... Or would it be sold to organisations rather than individuals? ... Where could it be sold? ... How long would it last? ... Or how often would it be used?'

This led to issues of marketing, which Ken realised was a difficult concept for the students. He did not assume the idea was understood, but supported students in thinking about it, and elicited their understanding. He recorded suggestions from this discussion on the board:

- What is the market?
- Are you going to sell it?
- Consumer group?
- Price?

Doing this provided a model for the students to use as they worked on their presentation and so supported development of understanding of the concepts.

In this classroom we observed high levels of interaction between students and between students, teacher and mentor. Students' ability to work together with shared understanding, developed noticeably. Progression in students' critical thinking was evident in their work, and the development of the designs showed creative insights as students combined and reinterpreted existing ideas in new ways. All of the product ideas were individually creative in the sense of being novel within the group creating them. The teacher commented on the unusual levels of engagement and concentration of all students, and the general level of excitement and interest. The students concurred with this and said they would like to do the programme again.

Jerry was interested in the way the Young Foresight programme supported risk-taking in collaborative discussion, promoted confidence, and helped students to 'recognise that design is wider than, *here's something you've got to design, here's something you've got to make ...* that requires people to be innovative and fresh thinking. Creativity is important but you've also got to have a practical thinking process as well'.

In a phase 1 session, he focused on the key learning issues within it: 'If you look at the trends for today we can maybe get a clue of how things might be going on in the future.' He discussed with the students their experiences of trends in relation to developments in the designs of bicycles and cameras that were highlighted in an accompanying video, allowing him to establish common ground between students. He ensured that students were aware of the salient issues so that they could watch with an informed view and purpose, and afterwards used whole class discussion to make connections between the video and the past and present industries, history and geography of the students' home town. He provided a context for their learning that was relevant to their lives.

Jerry: *Until the beginning of the century [this city] was the bike capital of the world. [The city] was the largest producer of bikes in the world ... the [market leader's] works were just down the road and this area where we are now was dotted with bike works. You know the Olympic gold medal winning bicycle that you saw on the video, can anybody tell me where that frame was made?*
Student: *In this city?*
Jerry: *Yes.*
Student: *Around here, V. Street?*
Jerry: *No a bit further away ... It was made in P. Road that ... carbon fibre frame, and that road.... has been the centre for carbon fibre manufacturing in the world. The [company's] factory are world leaders so [this city] has kept in the bike world.*

Jerry finished the session by connecting its learning goals with what was to come, allowing students to see the direction of their learning: 'You have been thinking about the way things change by looking at the way things have changed in the past. It might help us to think a little bit about how things might start to change in the future.'

Jerry's approach is predicated on a view of the learner as an active constructor of meaning, in which students do not receive information passively but have actively to make sense of it.

In a Phase 2 session, Jerry and the mentor were discussing with a group of students their ideas for a diagnostic 'medical hat'.

Student: *We've got this idea for a medical hat and the team has done the needs assessment ... It's got to have contact with the head, it should be comfortable, it's got to be fairly lightweight, and it's got to be breathable.*
Jerry: *Why has it got to be breathable?*
Student: *Because we thought that your scalp would get sweaty otherwise.*
Student: *It's got to be able to tell people that you're ill, we talked about this chameleonic sort of glow-worm type thing. It's got to be able to take your temperature and give instant information.*
Jerry: *Does it have to be acceptable to other people to look at?*
Student: *It's got to comfort you and give you reassurance, so we imagined people lying down and it has little speakers and it talks to you.*
Mentor: *Are there any disadvantages to it actually being a hat that fits over the head? For example, certain members of the community who have to wear something on their head all the time wouldn't like to remove it. Or the fact that people have got lots of different head sizes.*
Student: *It would just stretch enough.*

The discussion raised various considerations about the product's development. The dilemmas that had been identified by Jerry and the mentor's contributions encouraged the students to engage in critical thinking about their design, but decisions about resolution of the dilemmas remained with the students. Students, teacher and mentor worked collaboratively in a way that provided a model for how to act when groups of students were working alone.

Ken and Jerry adopted similar pedagogies to deliver the Young Foresight programme and as a result their students were able to engage in problem solving activities throughout their design work. The outcomes were creative in that the ideas developed were novel to the students, but also the process was creative in the opportunities it provided for students to engage collaboratively, and in a reflective and critical way, with each other.

Discussion
In conventional design and make activities, the majority of the dilemmas that the students encounter are within the making stage. Although design is deemed to be important and several ideas may be produced before making a choice, the majority of a student's time is spent in making. The Young Foresight programme shifts the focus of problem solving to the design alone and freed from the constraint of needing to make the design, the potential for a variety of creative solutions is much greater. In addition, the Young Foresight programme encourages student collaboration through teamwork so providing a more effective setting for critical review.

In Ken's and Jerry's classes, the key to creative problem solving lay not in choice of design tasks, since those were dependant on the scenarios developed by the students, but in the way the teachers were able to provide a successful learning experience.

They were particularly effective in:

- making the lesson task and content relevant to the students' experience and concerns
- building conceptual and procedural knowledge by providing models and frameworks that students could adapt to their situation
- making learning explicit and showing how it fitted into the overall experience
- supporting collaboration
- enabling students to encounter and deal with their own dilemmas
- developing interactions that engaged with students' thinking but left decision making with them so maintaining their autonomy.

The Young Foresight approach, with its emphasis on collaborative design, is a more authentic representation of the nature of design in commercial practice than that found in individual design and make activities. However, it also raises a major concern for teachers in that it only partially supports the assessment criteria for Key Stage 3. The challenge then is how to combine the strengths of both approaches. Only modest shifts of practice would be required for aspects of effective pedagogy, seen in the Young Foresight programme, to be applied to design and make activities. Doing so would enable the aims expressed in the National Curriculum Order for design and technology – 'learn to think creatively to improve the quality of life ... become autonomous and creative problem solvers ... look for wants, needs and opportunities and respond to them ... with an understanding of ... social and environmental issues, function and industrial practices' (DfEE, 1999) – to be achieved.

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