

Young children's problem-solving in design and technology: towards a taxonomy of strategies

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Abstract

Design and technology tasks make great demands on young children's conceptual and procedural knowledge, yet little is known about the problem-solving strategies young children bring to these activities and how these strategies might be expected to develop in the early years classroom. The present research aims to identify and classify children's emergent, developing and changing problem-solving strategies in a longitudinal study and to trace these throughout Key Stage 1. The phase of this work described in this article looks closely at children engaged in design and technology tasks in two schools and describes the strategies they use. The children were observed through reception, Year 1 and Year 2 engaged in six different design and technology tasks. An attempt has been made from this data to generate units of analysis towards creating a taxonomy of young children's problem-solving strategies. These strategies appear to be inter-related developing from and building upon one another to form strategic patterns or styles. Questions emerge concerning young children's personal strategic style and the most effective strategies children use for solving problems in design and technology at this stage. It is suggested that an awareness of a taxonomy may help primary teachers to understand children's 'intuitive' ways of working and to offer the most useful support at the most appropriate time when guiding children through design and technology tasks in the classroom.

Background

Primary design and technology is a relatively new subject area without a tradition or clear definition and is generally acknowledged to be still finding its place in the primary school curriculum. Although teachers work hard to make sense of the National Curriculum documents they are demanding and difficult to interpret. The body of knowledge to which teachers and pupils should relate is not shared in a way that might develop skills, knowledge and technological understanding [McCormick, 1994]. The Open University PSTE Project [1995] confirms that technology tasks make greater demands than is often realised on children's conceptual and procedural knowledge. At Key Stage 1 questions have been raised

concerning whether this work is appropriate for young children and how they will cope [DFE, 1994]. OFSTED [1995] claims that Infant teachers need guidance as to what they should be teaching based on a clear conception of what young children can do. Yet little is known about the problem-solving strategies young children bring to design and technology tasks and how these might be expected to develop in the classroom.

The development of children's strategies needs to be situated however within a theoretical framework that encompasses what we know about children's psychological development and particularly the notion of cooperation in problem-solving, since this is an essential requirement of working in design and technology. There has been a great deal of research on children's cooperative learning. Perret-Clermont [1980], and Doise and Mugny [1984] combined Vygotsky's ideas on collective cognition and its social origins and Piaget's investigative tasks to study how groups of young children learn from each other. Work on the zone of proximal development has been extended by Rogoff [1990] in her idea of the child as apprentice, but a less passive view of the child as problem solver engaged in activities which present authentic dilemmas, exists in the work of Lave [1992]. This situated cognition stance offers a view of cognitive processes that differ according to the domain of thinking and the specifics of the task and context. It values the intimate connection between knowing and doing and views learning as a process of enculturation through shared activities into a community of practice [Wenger, 1991]. This literature seems appropriate to learning in design and technology as it focuses on three essential aspects of the activity. It centres on how the context of a task affects children's strategies during problem-solving, on how children might be inducted into a process such as design which draws upon industrial and cultural models, and on how the content of knowledge, skills and understanding of technological activity is introduced to children.

Interestingly there is very little analysis of the kinds of problems pupils face when they undertake technological activity. For

example, Waetjen [1989] in his review of the field does not discuss the nature of the problems to be solved. However, new work by Kimbell and Stables [1995] has begun to investigate the different experiences that pass for problem-solving in design and technology across the primary and secondary age range. In the present study the design and technology tasks themselves provide a potential area of enquiry. What are the nature of the strategies children employ for various tasks? Do children employ similar strategies when faced with tasks of a similar nature? The National Curriculum for Design and Technology may tend to assume universal designing and making strategies for all tasks [NCC, 1990, DFE 1995] but do children intuitively use the same strategic repertoire regardless of the problem to be solved? Might they be expected to exhibit a different range or combination of strategies when designing and making moving vehicles or clay gifts, as these tasks may require children to use different resources, knowledge and skills? Are there strategies which cut across tasks and others which are task specific?

The research

The aim of this present study is to look closely at children engaged in design and technology tasks across schools and try to describe the strategies they use. The sample consists of 36 children, in two infant schools, each class organised into three groups according to age and experience in school. The children were observed through reception, Year 1 and Year 2 engaged in six different design and technology tasks. Analysis of the transcripts was done through systemic networks [Bliss et al, 1987] and open coding techniques [Strauss, 1987]. From this work an attempt is being made to find a taxonomy of children's problem-solving strategies in design and technology. The analysis of the data is still in progress but initially a sequence of qualitative procedures were used; open coding looking for categories, axial coding revolving around the axis of these categories looking for patterns and relationships, and selective coding focusing in detail on these categories and patterns. Then links were made across transcripts in an exhaustive technique [Strauss and Corbin, 1990]

This article presents some of the units of analysis generated by the work together with some supporting examples from the transcripts and considers the match between them towards creating a taxonomy of young children's problem-solving strategies. Here are some examples of Year 1 children's strategies taken from the transcripts of sessions in two schools. The task for the children was to design and make a model building of their choice. It was planned by the class teacher as part of a cross curricular topic on buildings following the building of an extension to the Infant department of the school.

At the beginning of the session pupils explored the boundaries set by the task. Presented with the initial activity of evaluating other children's model houses the children checked the frame of the task, attempting to relate to what was required of them by **personalising** it but also making sure that they understood what counted as a building. They strive to make sense of the concept of 'a building' as seen by the teacher.

CHILD: Does it have to be a house ?

RESEARCHER: No.....?

C: It could be another building?

C: Or a Big Ben?

R: Big Ben, yes that's a building.

C: The statue of Liberty?

C: A shed? My dad's got a shed.

R: A shed, yes.

C: Sky scraper?

R: A skyscraper, yes.

C: A garage? Like one for our car.

C: A castle?

C: Church

C: Shop? I like sweet shops!

In another session on the same task older Year 1 children **negotiated** the boundaries of the task by asking,

C: Are you allowed to make a newsagents?

C: No, that's boring

C: Wait a minute, wait a minute...a

hideout I saw it on the newsit's a dugout..... but you can still live in it.

C: A shoe shop?

R: A shoe shop, and I suppose you could make a dugout but it's stretching it a bit.

Later in the session the same child **talked himself through** the task he had set himself. He had **reposed** the original assignment to suit his personal wants and needs:

C: I started at the top and ... what I did... yesterday on the news I saw a soldier's dugout... I'm making a little hideout.... where I can dig in... the other children don't have a hideout... I'm safe in here... you're leaving.

The children had now decided what to make and were given hard material and tools. They realised that they needed to **practice** certain skills before designing and making:

C: I need to have a little practice first with the tools.
C: Ah, I need a go tool [at sawing wood]
C: Can I see it again? [use of hacksaw and bench hook]
C: ... sandpaper? [examining sawdust]
C: No
C: I've got some in my shoe [sawdust]
C: It's a mess
C: I got some
R: Have a little touch. [saw] You turn there and then you go like that. That's it, don't press too hard.
C: Oh
R: Go on. Careful, not too hard. Pretend you're cutting through butter and it's very easy. Softly.
C: I've cut a tree down you know!
C: So have I!
C: I don't believe you
C: I cut my plant down. I cut all the leaves off.
C: Did you really?
C: I've cut my fingers before
C: I don't need this bit. [rest of wood]
C: Put it there [in box]
C: Is it tricky?
C: Is it hard?
C: Yes, it's a bit tricky 'cos you see the thing was stuck. [hacksaw]...

Later in the session the group discussed making a drawbridge. They **identify their needs** in terms of both the material and human resources

C: You can do it this way [offers wood to make a handle]

C: No... it's harder now.. because you've got to wind one round as well haven't you?

C: You've got to wind the string round and hold the top and hold the piece of wood too.

C: You need three hands.

R: You're quite right.

C: What is that... he has got three hands!

C: He's got three hands ...

R: Because his friend is helping him

C: Seems easy now...

As the session progresses the children often see the value of **sharing and cooperation** becomes even more apparent to the group:

C: Matthew can you hold that please?
C: Tom... can you stick this?
C: Right... enough... [glue]
C: like that?
C: Yes.
C: It's sticking.
C: Now this bit for the roof

Towards the end of the session the children see the need to **persist** and work hard but often experience difficulty collaborating and may create a **panic** situation:

C: Can I have a felt pen please... is there a pen around here?... erm... can I have a pen over here?
C: Richard, how come you never say please
C: Er herrm can I have the penplease.... pen please somebody
R: You've done very well...
C: Quick! Quick! The roof's collapsing
C: Hold it there...
C: Put that there...
C: Help...Help
C: oohhh. Oh God, Oh God! It's going to fall.
C: Miss... I can't do the turrets...
C: Can I have the pen please... you've had it long enough...
C: You're mean!..
mean!...mean!.....

To date a number of children's problem-solving strategies have been identified from the data. These units of analysis illustrate how a taxonomy of problem-solving strategies may begin to be identified and described. Some of these strategies may occur at the start of a design and technology session, some at the end and some may recur cyclically throughout the lesson.

Towards a taxonomy

Personalisation

Children seek to relate the task to themselves and their personal world. The aim of this strategy for the children seems to be to make links with past experiences of a similar nature or to promote feelings of security and self confidence. It enables the child to attempt to bridge the gap between 'school knowledge' and 'home experience or personal knowledge'.

Practice

The purpose of this strategy is to gain experience of manipulating or working with tools or materials. This strategy, like personalisation, may be revisited many times throughout the activity especially when new knowledge and skills are needed. Children can become so preoccupied with managing and manipulating the resources that practice or self directed play takes president over problem-solving. Boys in particular can become carried away with sawing wood and forget the original task.

Identification of needs

This strategy works on three levels, relating to materials, people and places. Children recognise the resources they need to carry out the task in terms of tools and materials and choose appropriately from the range available. They ask for alternatives according to their own requirements, priorities or personal taste. They also identify the demands of the problem in terms of the knowledge, skills and confidence required to tackle the task and request individual or cooperative working arrangements or different contexts in which to work.

Negotiation and reposing the task

The aim of this strategy for pupils is to explore with the teacher the boundaries of

the task and seek to work within what is 'allowed' within the classroom culture while satisfying their own wants and needs to investigate and manipulate tools and materials. As a result of negotiation they may alter or completely change or repose the problem-solving task to suit themselves. Negotiation can revolve around the overall task or sub-tasks within it.

Focusing down

The children use this strategy to interpret the task. They describe and explain the task to themselves specifying various components and expounding them in order to determine the exact nature of the problem. This strategy enables children to be continually clarifying in detail what needs to be done.

Identifying difficulties

As in identifying needs this strategy concerns three areas: materials, people and places. As the children move through the task they begin to pinpoint predicaments in working with the materials and problems concerning availability of resources. There is a growing awareness of difficulties in working alone but conversely problems with sharing are also identified. Children may also identify difficulties in working space and in safety aspects.

Talking themselves through sub-tasks

During problem-solving young children use self-directed or egocentric speech as a strategy to accompany their own actions. This is externalised thinking. This thinking aloud allows them to reflect upon what they have done, be alert to what they are doing and tell themselves what to do next. This strategy heightens self awareness and aids planning.

Tackling obstacles

This entails children working on the difficulties they have encountered so far. They become aware of making mistakes and begin to use a range of ways of overcoming difficulties and mastering skills. These solutions are still being documented but may include technologically pragmatic, cooperative and help seeking strategies. Young children may also bring their experience of personalising a problem to

bear by mentally calling up incidents of similar challenges at home.

Praise, encouragement and seeking reassurance

The children seem to use these strategies to support each other and gain confidence. They are often reciprocated giving children a feeling of growth and well-being and creating a comfortable and mutually beneficial atmosphere in which to work. Children will show and sometimes depreciate their work in order to be reassured. These strategies serve to reflect on progress, stimulate perseverance and inspire fresh ideas.

Sharing and cooperating

Here children give advice and assistance, with and without being asked for it. They begin to show their problem-solving experience and use it to help their peers. This help concerns sharing their growing appreciation of which tools, materials and techniques are most appropriate in a given context. They ask detailed questions concerning procedure and seek specific support based on a firm understanding of the competence needed to extend their capability. At this stage they may have an end product. These strategies allow children to confidently use the knowledge and skills gained throughout the task to help each other to look critically at the quality of the product and modify or change it.

Pretend panic and persistence

These two strategies are used towards the end of a session. It is thought that they are the result of sudden awareness of the lesson coming to an end and the amount of work that remains to be done. Tiredness and lack of concentration are two factors here and children may have difficulty in sharing, squabble over resources or have small accidents with tools. Some children persist with the task regardless while some use a pretend panic to attract help and propel everyone into action. Girls are particularly good at this. Sometimes however children call upon a source of support they have used earlier in the activity and friends and teachers can be crucial at this time in providing encouragement and helping to create a successful outcome.

Conclusion

It can be seen that these units of analysis are not necessarily separate or clear cut but converge and overlap. The strategies are inter-related and not isolated but develop from and build upon one another. Children revisit aspects of a previous unit and add new dimensions, gradually incorporating fresh strategies into their problem-solving as they move through the task. However, on occasions a child may become preoccupied with a certain area of interest within a unit and cannot seem to move on. In this case and throughout the design and technology task, an awareness of a taxonomy may help teachers to understand children's 'intuitive' ways of working and to offer the most useful support at the most appropriate time. Do individual children have their own strategic pattern or problem-solving style? A taxonomy may help primary teachers in knowing when to intervene and when to stand back: one of the most difficult dilemmas when guiding children through problem-solving in design and technology in the classroom.

This analysis is at a very early stage but it seems that certain strategies may occur in a common sequence in tasks of a similar nature where the same kind of resources and materials are available and similar techniques appear to be required. May it therefore be possible to compare same task design and technology sessions for same age children using this taxonomy? Could the way children of different ages tackle the same task be compared using these units of analysis? May comparisons be made between different tasks focusing on taxonomy that are task specific or perhaps those that are task transcendent? Much more work needs to be done.

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LOUGHBOROUGH UNIVERSITY
DEPARTMENT OF DESIGN AND TECHNOLOGY

MIKE HALL
1939-1996

Mike Hall died on 16 December 1996, following a six-month battle against cancer.

Mike joined the Department of Design and Technology at Loughborough in January 1968 (when the Department was part of the former College of Education). He had been a consultant designer working in, especially, the materials area of plastics. He brought his specialist knowledge, understanding and expertise to the department, and continued also to practise as a consultant throughout his teaching career. Having worked with thousands of students and serving teachers, his work was a major influence in bringing plastics into the technology curriculum. Typically, when I visited Mike, his concerns were for his students and for news of their progress. He was continuing to read widely; he was pursuing research into semiology and the design of electronic consumer goods; and he was preparing a book for publication. Mike had a marvellous ability to recall the students he had worked with, including those from his earliest days in the department; and many have expressed their great sadness on learning of his death, and have spoken of their appreciation for his gifts as a teacher and designer, and as a counsellor and guide both when they were Loughborough students and in their later careers. All this he did quietly, and with infinite patience and kindness; he was a fine teacher and designer, and a generous and sensitive man.

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