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Can young children mentally rotate an image on a 3-D block and consequently make a prediction based on this mental rotation? Can they also see from another's point of view?

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Can young children mentally rotate an image on a 3-D block and consequently make a prediction based on this mental rotation? Can they also see from another's point of view?

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Abstract

Imaging or 'seeing in the mind's eye' is one of the cognitive skills involved in the process of designing. It allows us to create internal models, enabling us to plan how things might be and speculate about the future. Mental rotation of an image or an object is part of this process of visualization and an essential cognitive skill in designing, but are young children able to rotate mentally?

This paper grew from a case study with a child and forms part of a much larger research project into the emergence of design capability in the early years, with particular reference to modelling.

Introduction



Figure 1

At the age of four years and eight months, Joe, the subject of the case study was at play. During the course of this play he had drawn Thomas the Tank Engine on a wooden block. Taking the block, I rotated it slowly a quarter turn each time in a clockwise direction and asked him at each turn if he could see Thomas and whether he thought I could see Thomas too. My final question was to ask him to predict who would see Thomas if I rotated the block one more time in the same direction. His responses were immediate and correct each time. During the course of this task I was able to ascertain whether Joe was able to-

- *Mentally rotate an image on a 3-D block*
Evidence for this was that he could tell me when he could see Thomas, and when I could see Thomas from my point of view.

- *Mentally "see" from my point of view*
Evidence for this was that he could tell me when I could see Thomas.
- *Make a prediction based on the rotation of the image on the block*
Evidence of this was that Joe made the correct responses at each rotation and was then able to predict correctly where the image would be if the block was rotated one more time.

The above then became the objectives for the following activity which I piloted with nursery children. Were children of a similar age to Joe capable of displaying the same skills? I began by telling them that what I was interested in, was what they were thinking. I then presented them with the block with the image of Thomas on one stretcher face. I then showed them the image on the block and asked them what they could see. All the children identified the image as a train or "choo-choo". I then turned the block and added in a trick question to ascertain whether their answers were reliable or not. The question was - "Could they see the monkey on the block?" For those children who correctly answered that they could not, I made it clear that this was a trick question, but the rest of the questions were not.

I then went back to the image of Thomas and began to ask whether they could see Thomas

and whether I could see Thomas too. I then rotated the block slowly, telling them that I was doing so and indicating the direction of turn with my forefinger. The image at this point was facing me, but I found that some children could not tell me that I could see Thomas. Did this necessarily mean that they did not know where the image was located? Could they, in fact, indicate to me where the image was even if they had just told me that I could not see it? I made the question as explicit as possible - Can I see Thomas from where I am sitting? After this question I decided to ask each of them to point to where they thought Thomas was, without actually

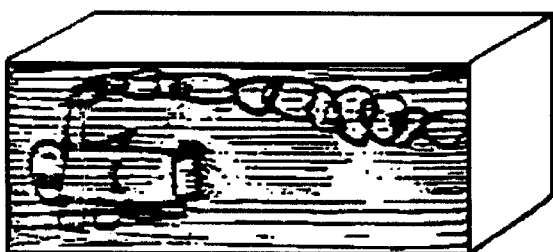
jumping up to look. A correct indication of the location of Thomas was confirmed. Some children could point to where Thomas was, but not see from my point of view.

After piloting and revising the questioning, I undertook the following activity with 30, three to four year olds in nurseries in Leeds. Where the opportunity existed, this was conducted on a one-to-one basis in a separate room; it was otherwise conducted in the quietist area of the nursery. This did not appear to distract the children in any way. The following script was used.

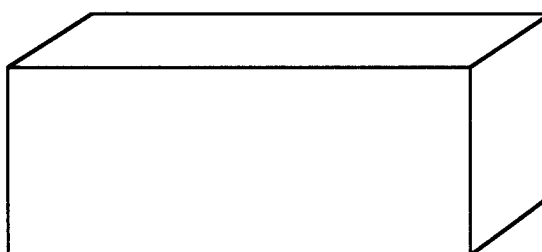
Rotations of the image of Thomas the Tank Engine on a 3-D block

Face visible to the subject

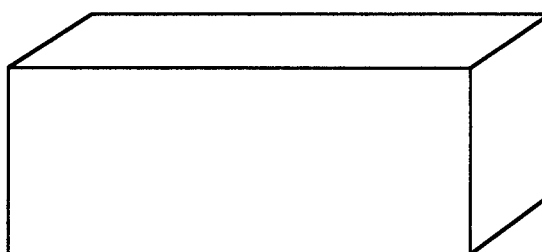
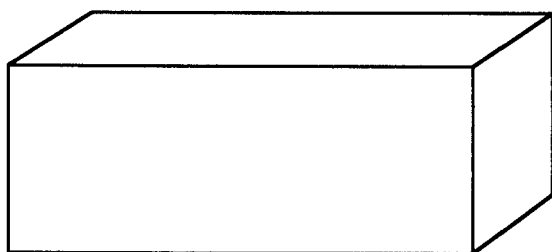
1 What can you see?



Face visible to the turner



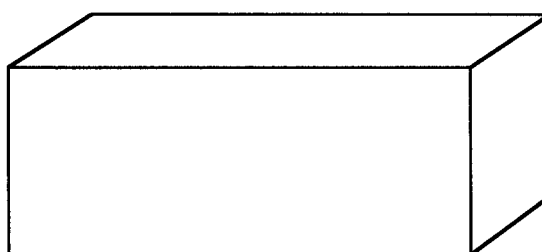
2 Can you see the monkey on the block?



3 Can you see Thomas?



Can I see Thomas from where I am sitting?

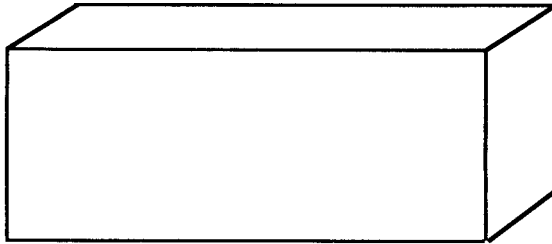


4 TTE underneath

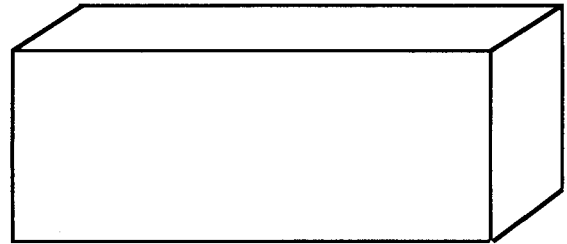
Who can see Thomas now?

Can you?

Can you point to where Thomas is now?



Can I see TTE from where I am sitting?

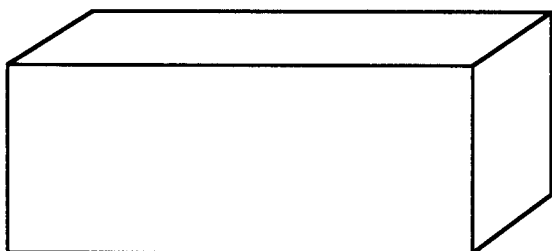


5 TTE facing turner

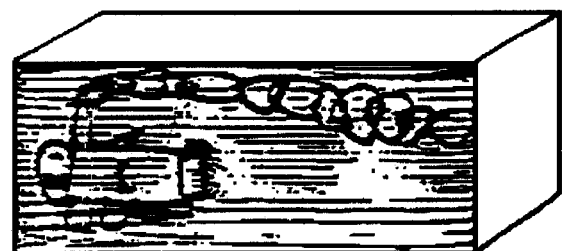
Who can see Thomas now?

Can you?

Can you point to where Thomas is now?



Can I see TTE from where I am sitting?

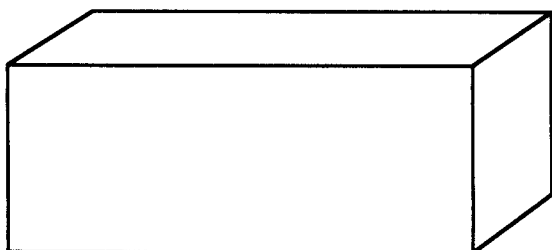


6 TTE uppermost

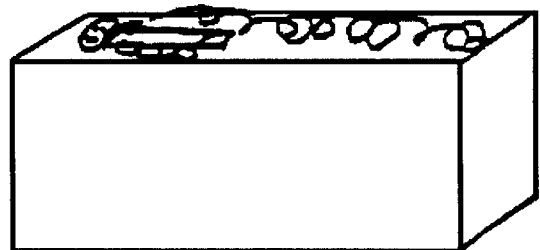
Who can see Thomas now?

Can you?

Can you point to where Thomas is now?



Can I see TTE from where I am sitting?



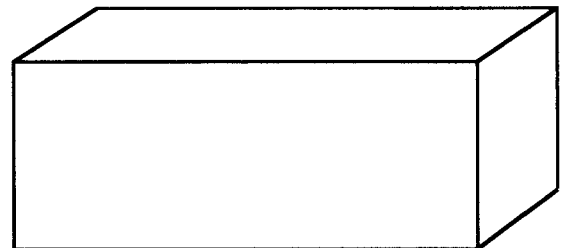
7 Prediction of rotation

If I turn the block one more time this way (indicated direction of turn with finger) who will see Thomas?

Will you see Thomas or will I see Thomas?

Shall we check?

(Check then made)



i) Can young children mentally rotate an image on a 3-D block ?

Three children out of the thirty, two girls and one boy, completed a 360 degree rotation of the image on the block, including the prediction of rotation, and were able to see from my point of view. Their ages were 4.2, 4.4, and 4.8 months. Two more children were able to rotate mentally the image on the block 90 degrees and were able to point without hesitation to where Thomas was on the underside of the block. Twenty children mentally rotated the image through 180 degrees, pointing accurately to where Thomas was, that is facing me. Nineteen of these children were capable of rotating the image at 90 AND 180 degrees. However, only five children could go on to make a correct prediction based on the rotation of the image on the block.

Piaget and Inhelder believed that children could not transform mental images until they were seven or eight,

....we found that kinetic anticipatory images were not formed before the beginning of the concrete-operational stage (p196).

They expressed the view that imagery played a special role in the thought processes of young children but that imagery was static and egocentric in young children. These findings run counter to this view.

ii) Can young children see the image on the block from my point of view?

When the image on the block was facing the subjects, five children said that I could see it also. When the image on the block was underneath and neither the subjects nor I could see it, twenty two answered correctly and knew where Thomas was, indicating by pointing. They also said that I could not see Thomas either.

When Thomas was facing me and I could see Thomas but the subjects could not, twenty children rotated the image and indicated where Thomas was by pointing, but only twelve said that I could see it from where I

was sitting, leaving eight children who could not see from my point of viewpoint. Two children throughout the task declared that I could see or not see whatever they could see or not see. These were children who successfully indicated where the image was and went on to make successful predictions even though they were not able to see from my point of view.

Six children provided evidence that they could only see from their point of view, telling me that I could see exactly what they could or could not see. This only gave a correct response when Thomas was underneath and visible neither to the subject or myself. There seems to be a problem with seeing from the viewpoint of another, but only with a small number of children.

When Piaget (1956) presented his 'Three Mountain Task' to children he sat them on one side of the mountain and a doll on the other. They were asked to select pictures of the mountain models from different angles, showing the views that the doll could see. Children below the age of nine failed in this and those under seven tended to depict their own point of view. Implicit in this task is that children have a conceptual grasp of a sighted doll. Piaget became convinced that young children could not decentre and therefore could not see from another's point of view. Further research has challenged Piaget's findings. Light and Nix think that the subjects are likely to have chosen their most desired view, that is, the 'best view', rather than illustrating the priority of 'own view' over 'other's view'. In a perspective taking task conducted by Light and Nix children between the age of 4-6 were found to have an 'own view' preference, subject to an over-riding concern to select a 'good view'.

The evidence from a task undertaken by Flavell also runs counter to Piaget's findings. In an experiment conducted by him and cited by Hobson (1982 p45), children were presented with a cube that had different pictures on the four vertical faces. The experimenter had an identical cube, which he turned round. The children were then asked to do the same with their cube so that they could see the same picture that the experimenter was seeing.

Three out of ten three year olds responded correctly and seven out of ten five year olds. Hobson also conducted a modified version of this test using a block with coloured faces and a doll named Fred. He found that children in the pre-operational stage did demonstrate an ability to see from another's perspective.

Hughes, cited in Donaldson (1978 p21), conducted his own experiment. He used two "walls", intersecting to form a cross, and a small boy and a policeman doll. Some pre-training was given and errors pointed out. From a sample of thirty children between three-and-a-half and five, 90% got it right. The high success rate was attributed to the scaffolding provided by pre-training and the realism of the context.

The task I presented differed in many ways from the above tasks, but the results do show that many three and four year olds can see from the viewpoint of another person. Only two children said that I could see whatever they themselves could or could not see.

iii) Can young children make a prediction based on the rotation of the image on a 3-D block

The final question in this activity was "If I turn the block one more time this way, who will see Thomas. Will you? Will I?" I was aware that some children may desire to see the image and have a good view. As evidence of prediction I therefore based this on whether the subject had provided evidence of rotating the image through all previous rotations. Only three children, two boys and one girl, responded correctly, based on knowing where the image was and viewing it from my perspective also. Two more children were able to rotate mentally the image on the block and make a successful prediction, but they were unable to see from my point of view. Only one child was unable to provide evidence of any mental rotation at all.

Conclusion

The findings from this task are that one in ten three to four year olds could complete a 360 degree rotation of the image on the block, see from my viewpoint and make a prediction about a further rotation. Their ages were 4.2,

4.4 and 4.8. While I think that the block itself was being rotated I cannot confirm this with any degree of confidence, but the evidence indicates that the image was being rotated as the children gave evidence of this by pointing to its location and sometimes by saying that I could see it also.

Two more children could mentally rotate the image, indicating its location, but could not see from my point of view. These children were able to make a correct prediction, therefore five children in all were able to rotate mentally the image through 360 degrees and make a prediction based on this rotation.

Twenty two children were able to rotate the image through 90 degrees, correctly pointing to its location.

Twenty children mentally rotated the image through 180 degrees, pointing to where the image was, that is, facing me. Only one of these children had not mentally rotated the image at 90 degrees as well.

I believe that education largely fails to make children aware of their capacity for mental imagery and manipulation of this imagery. Opportunities exist in most areas of the curriculum to develop this but are not taken up. How many times are children asked to design and make something without being called upon to visualise and then communicate their internal models or ideas? Through manipulation and rotation of mental images we can explore many possibilities. Shepard (1978 p134) says,

It is the possibility of performing dynamic operations with such images that confers on them much of their creative power.

Visualisation is part of the process of designing. To plan ahead and foresee how many things might be we need to be able to manipulate and control them in our mind's eye. Cocking and Copple rightly say that,

... without the ability to form mental representations, we would be unable to plan. Planning how to arrange the living room furniture, how to drive to the shopping mall....the formation of mental

representations of spatial arrangements, object transformations... without this representational capacity, we could not make the simplest plan. (1987 p428)

If children can plan ahead mentally, then they can modify their plans before producing a product. Being able to rotate an image or object mentally allows us to plan how a product might be, and even allows us to evaluate the product before it has been made. As an excellent example of someone displaying this capacity to a remarkable degree, McKim (1972 p10) cites Nikola Tesla. Tesla, whose inventions include the alternating current motor and the fluorescent light, was especially skilled in mentally manipulating and rotating images. He had the ability to trial and test mentally a product he intended to make, even to the point of mentally disassembling it and examining components for signs of wear.

The importance of such imagery and manipulation of those images in children's thinking is a cognitive skill that is not adequately developed in school. It tends to decline as they move through school because we do not place sufficient emphasis on this aspect of children's thinking. Richardson says that,

With the emergence of more schematic and linguistically based cognitive processes the role of imagery declines in the majority of children who live in modern industrialised societies. (1969 p12)

We therefore need to make children more aware that they have the capacity to visualise, rotate and manipulate images so that they can enhance their mind's eye, use it more purposefully and think creatively during their designing and making. This research shows that some children from an early age are beginning to develop their capacity for mentally manipulating images. This capacity needs to be acknowledged, enhanced and developed. Thinking needs to be explicitly built into the National Curriculum. Fisher (1994) rightly says that teachers are not only

teachers of specific subjects but teachers of thinking and learning and strongly advocates a Thinking Curriculum with clear cognitive aims. I believe that visual thinking and all that it entails should be part of this Thinking Curriculum and be explicitly incorporated into the curriculum for Design and Technology.

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