WORKING WITH 3-D SHAPES - POLEIDOBLOCS

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With the current emphasis on literacy and numeracy in the primary school there needs to be concern that the mathematics curriculum does not become distorted to the extent that fundamental ideas other than number become neglected Using Poleidoblocs, the coloured building bricks that have been consistently among the resources in many classrooms since their introduction in the 1950s, we have looked at the development of ideas that relate their use to the requirements of the National Curriculum beyond number. Characterisingfree play and analysing children's responses to particular tasks has enabled us to jdentify developments in understanding of relationships among shapes and some ways they may be used

Introduction

Poleidoblocs is a set of 54 brightly coloured wooden bricks introduced in the 1950s by Dr Margaret Lowenfeld and currently remaining among the best selling mathematical equipment of NES Arnold. The set consists of bricks in 6 basic shapes: cubes, cuboids, cylinders, triangular prisms, cones and pyramids, that are interrelated in a number of ways. They are found in many primary classrooms and this study presented an opportunity to consider mathematical learning that can relate to their use. Using free play and structured tasks an analysis was undertaken of mathematical ideas including sorting and decision making, measurement, balance and symmetry.

Methodology

The main study involved 66 pupils in reception and year 1 classes in 3 schools and 7 individual children aged between 21 months and seven years. A total of 41 children were video taped during free play with Poleidoblocs, some individually and others in pairs, and all of the 66 children in reception and year 1 classes were observed individually undertaking 5 practical tasks with an observation schedule for recording responses. After the first tests, sets ofPoleidoblocs were left with selected classes and the children were re-tested 2 months later when some had further opportunities for free play while others had no further experience. Opportunities for language development are clearly available through interactions with children using the bricks but mathematical language was used inconsistently among the cohort, reflecting the varied language development of the young children. In order to minimise differences attributable to language development rather than mathematical understanding, the study focused on practical tasks where possible.

Initially children were video taped using the bricks in free play, and mathematical experiences that arose spontaneously were analysed. These formed the basis for tasks that were tried and refined. Mathematical experiences included

- *sorting* by shape, colour, size and function,
- *balancing* and intuitive *measurement,*
- aspects of *stability*
- ideas of *parallel, horizontal,* and *sloping* faces, *central* positioning
- *symmetry*

Observations of the free play

Video tape recordings were made in school of reception (n=17) and year 1 (n=17) pupils and casual recordings were made of 7 children between the ages of 21 months and seven years. In all of the children asked to participate by 'using the bricks' there was immediate enthusiasm and all spontaneously built towers or more complex structures. Certain characteristics appear to be related to the age and developmental understanding of the children. For example, the youngest child of21 months showed little sign of careful selection of the bricks but children from two and a half thoughtfully selected bricks by shape, colour, size and their function.

Awareness of the need for *parallel* faces, both *vertically* and *horizontally,* and the need to position bricks *centrally* in order to create stable (and aesthetically pleasing) structures was evident in many children as they carefully lined up and positioned each addition. This awareness was lacking in some reception and year 1 pupils whose structures were unstable.

Attempts to build on the *sloping* faces of triangular prisms or the *points* of cones and pyramids showed lack of understanding of the need for *horizontal* surfaces.

Many of the older children made *symmetrical* structures or added symmetrically to their existing constructions. Long and narrow cuboids enabled children to select *m/ferent faces* as the base and some of the older children clearly enjoyed the challenge of using the smallest faces to create carefully *balanced* structures. Intuitive *measurement* was again evident in the selection of appropriate pieces for building up or infilling spaces. Selection of bricks involved *sorting* for colour, shape and size. Some of the complex structures depicted some imaginative or action based use like Dan who built a catapult and Annie who constructed a marble run.

The older pupils generally built towers (82%) while reception children built complex structures reflecting they ways they were sorting the bricks. Some year 1 constructions were built completely *symmetrically,* sometimes with two bricks added simultaneously, one with each hand. Overall, 65% of year 1 pupils clearly had symmetrical elements in their constructions while only 24% of reception children included any symmetrical element.

Types of Construction

The constructions fell into 3 categories; single towers, symmetrical towers, and complex structures. Most of the younger (reception) pupils (59%) built complex structures working horizontally and vertically while few (18%) of the year 1 pupils worked this way.

Table showing some characteristics of the children's constructions

	structure			*sorting*		
	single tower	symmetrical	complex	sameness	colour	shape
reception (n=17)	29%	18%	59%	29%	12%	35%
year one (n=17)	53%	29%	18%	35%	18%	18%

Gender Differences

Some differences between the structures made by boys and by girls were considered and although there was little difference in those making towers the boys more frequently used the smaller faces

for building with cuboids (that is the long edge and the short edge of the slats) creating tall and carefully balanced structures and more girls appeared to focus on sorting. This could also reflect the boys focus on factors affecting construction while girls focused on factors affecting the representation they were trying to achieve.

Differences between boys' and girls' structures

		boy (n=15)	girl (n=19)
structure	single tower	47%	32%
	symmetrical	20%	26%
	complex	33%	42%
sorting	identical	40%	26%
	colour	7%(n=1)	26%
	shape	20%	26%
slats	long edge	40%	11%(n=2)
	short edge	40%	26%

Approximately the same proportion of boys and girls sorted the bricks for their constructions but the girls used colour more frequently while the boys usedidentical bricks. Sorting for shape was the most demanding as cubes and cylinders of different sizes were also in different colours. A small number of children (1 boy and 2 girls) used an alternating pattern in their constructions. Where representations were made there were evident differences as two boys built trains while there were girls who built a playground and a palace.

The tasks

From the initial observations, children showed differing awareness of characteristics of the shapes and how the bricks could be used. Five tasks were designed to relate to aspects of shape recognition, intuitive measuring, sorting and sequencing. The tasks were the following:

1. *Matchinll 3-D shapes to 2-D faces:* From an assorted set of 10 bricks, correct shapes had to be matched to outlines of 6 faces on a sheet of paper. This included square and circular faces of a cube and a cylinder, rectangular faces of a cuboid and a triangular prism and triangular faces of the triangular prism and pyramid. [For the post test the layout of the sheet was varied and a different sized cylinder and cuboid were used.]

2. *The tower:* A tower had to be built beside, and to the same height as one already constructed from three stacked bricks. A set of five different bricks was available to the child but matching the height was only possible when the triangular prism was included standing on a triangular face. [In the post test the tower was constructed using the same three bricks in a different order.]

3. *Tactile task:* A green cylinder was shown and the child asked to select an identical piece from a 'feely bag' which enabled touch but not sight of eight different shapes. [In the post test a red cylinder was used.].

4. *Sortinll:* From a selection often bricks the child was asked to select all bricks the same as the green cylinder and then all bricks the same shape . [In the post test a green cube was used.]

5. *Sequence/Pattern:* Each child watched as a sequence of bricks was placed in a line starting with red bricks in order; cube, cuboid, cylinder, cube, cuboid ..... The child was asked to continue with two further additions. [In the post test, the order of the bricks was changed.]

Results using the tasks - Initial-test

In all items year 1 children were more successful than reception, as would be expected. Both age groups experienced considerable difficulties with some tasks and found others easy.

Table showing successful completion of the tasks in the first set of tests

	reception (n=40)	year 1 (n=26)
covering triangle (tr-prism)	18%	31%
covering square (cube)	95%	100%
covering circle (cylinder)	85%	100%
covering rectangle (tr-prism)	3%	19%
covering rectangle (cuboid)	5%	35%
tower	20%	42%
tactile task	73%	88%
sorting task	40%	54%
sequencing task	25%	46%

Although the children were very successful at matching the square face of a cube and the circular face of a cylinder, only 18% in reception and 31 % in year 1 could match the triangular face of a triangular prism. Some children placed the correct brick on the 2-D triangle but could not orientate the brick to sit on its triangular face. This reflected observations of free play and performance on the 'tower' task where the triangular prism was used as a 'roof but not in any different orientation. Even more difficult was matching the triangular prism to a rectangular face different from the base of the 'roof with 3% successful in reception and 190,10 successful in year 1. The other rectangle to be covered on the sheet of shapes required a thin cuboid to be turned onto its smaller face and balanced upright.

In the tactile task where pupils were asked to select a brick identical to the green cylinder from a 'feely bag' all pupils selected a cylinder but some children in reception (27%) and year 1 (12%) selected a cylinder of a different size.

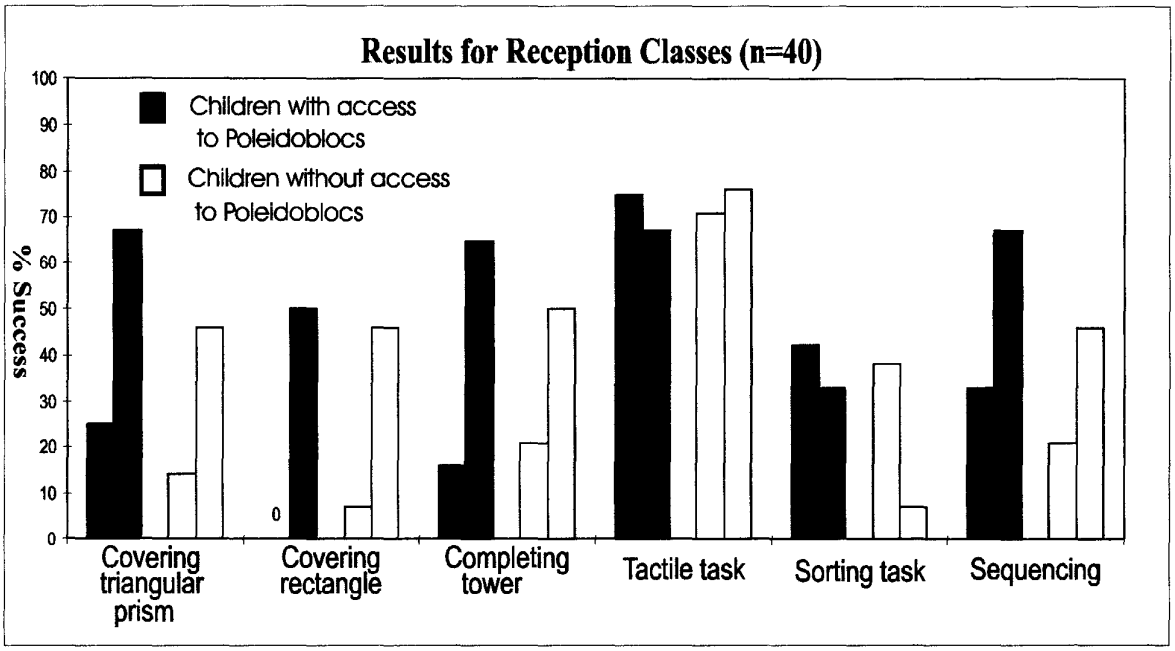
When asked first to select all bricks "the same as" a green cylinder and then add all pieces that "are the same shape", green cylinders were sometimes only matched with red (flat) cylinders or with blue (tall) cylinders showing that some pupils were reluctant to put in the same set the extremes of a thin cylinder and a tall cylinder. Some pupils added the cone to their selections having identified the circular face as the determining criterion.

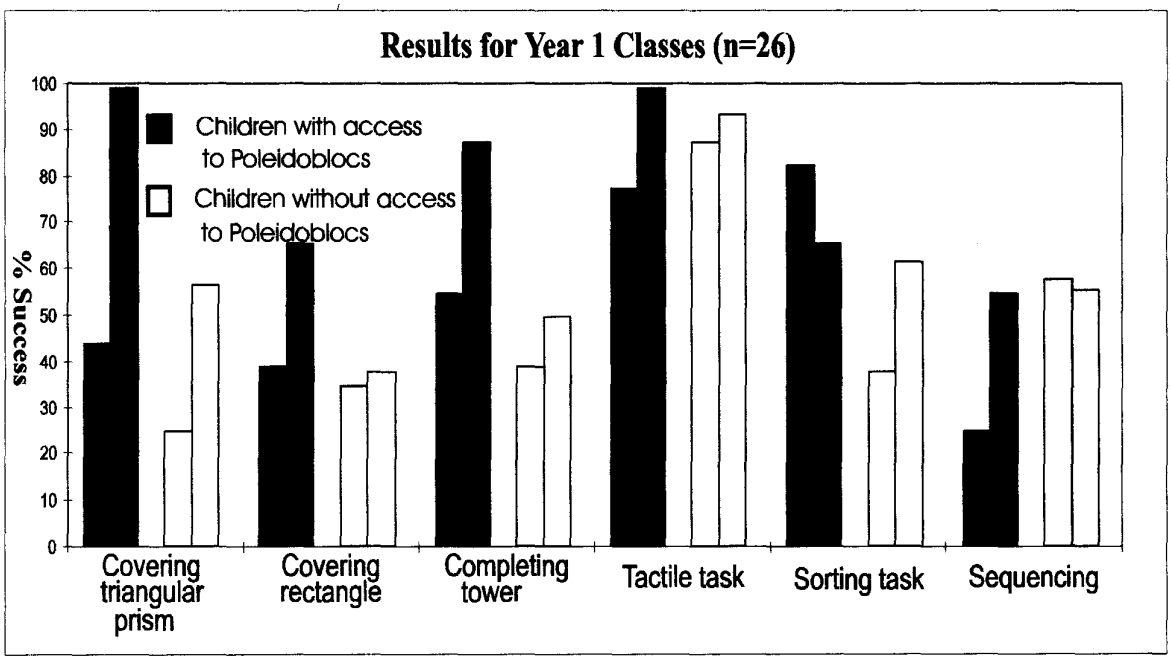
The sequencing task also proved to be difficult with 25 % in reception and 46% in year 1 successful. Having seen the sequence laid one brick at a time, many children could not identify the most appropriate shape to continue the pattern. Some selected the shape appropriately but placed it in the wrong orientation which shows partial understanding of the pattern requirement but again shows the difficulty experienced in re-orientating the shapes.

Results using the tasks - Second -test

When the same pupils were tested eight weeks later, half of the sample had opportunities for

additional experience with the bricks as sets were left in the classrooms. All pupils will have had opportunities to work with 3-D shapes as the classrooms had relevant resources and many children will have toys at home of a similar nature. On many of the tasks there was improvement for all of the cohort, with bigger improvements for those pupils having access to the sets ofPoleidoblocs. In some tasks however there was a deterioration in performance which will be discussed. The results for reception and year 1 are summarised in the following diagrams.





Matching faces and completing the tower

Substantial improvements can be seen in both year cohorts in matching the triangular face to the triangular prism and rectangular face to the cuboid with the biggest improvement (46% in reception and 45% in year 1) in pupils who had access to the Poleidoblocs compared with pupils without further access (16% in reception and 17% in year 1) [improvement on tasks together). The overall improvement may be attributed to the initial activities of having to try and match faces to 2-D shapes having heightened the pupils awareness of relationships between 3-D and 2-D shapes. Improvement in the tower building [41 % with further Poleidobloc experience and 22% without] also relates to the opportunity to handle bricks and change orientations while building.

On the other hand, the rectangular face of the triangular prism was matched by only one pupil in reception (n = 40) [second testing without further experience], 3 pupils in year 1 (n=26) with experience [no change between tests] and there was a deterioration of performance [down from 3 pupils to 1] in year 1 pupils without further experience. Normal construction activities with a triangular prism may involve using the triangular face or the 'roof base but pupils appear to have little experience using the other rectangular faces and have difficulty matching it to a rectangle. **Tactile task, sorting and sequencing**

The remaining three tasks involved recognition of the characteristics of shapes through sorting for sameness in some way. Changes from the initial -test to second -test in the tactile and sorting tasks has made immediate comparison difficult because substitution of the green cube for the green cylinder introduced different pupil experiences. In the pre test pupils were reluctant to class together the tall narrow cylinder and the short fat cylinder. Because of the symmetries of a cube, there was no extreme comparison in perception as there had been with a thin and a tall cylinder. There was however a strong identification with the square, and the error most pupils made in the post test was not in omitting any cubes but in adding the flat red rectangular cuboids to their set of cubes. This accounts for the deterioration in performance in both groups including those who had further experience of using the bricks. It is significant that there was no related discussion with any of the cohort whereby language and concepts of the cube and its square faces may have been clarified.

Conclusions

From the results of the tasks and the observations offree play it is apparent that children learn about 3-D shapes and their properties by handling them and using them in constructions as well as viewing them. Improvements on the matching and building tasks shows that performance is improved with additional experiences, particularly with the materials used in the tasks.

Tactile and visual experiences led to improved performance where classification was not required but deterioration in some tasks indicate that this type of experience is not adequate. Discussion involving the names and characteristics of the 3-D shapes is necessary for children to clarify mathematical understanding, for example, in the relationships between cubes and squares and the classification of cylinders that look different, being tall and thin or short and fat.