by Miss Ville Andersen DICP, Mr Robert G Thornhill and Mrs Marjorie Smith With an introduction by Dr M Lowenfeld FRC Psych.

The Material<br>by Ville Andersen, D.I.C.P.

## Poleidoblocs G



## Contents

The individual blocks of Poleidoblocs $G$ are cut in six basic shapes: cubes, cuboids, cylinders, triangular prisms, cones and pyramids.

Cubes: four $2 \times 2 \times 2$ ", four $1 / 2 \times 1 / 2 \times 1 / 2{ }^{\prime \prime}$, eight $1 \times 1 \times 1^{\prime \prime}$

Cuboids: four $6 \times 2 \times 1 / 2 "$, four $4 \times 2 \times 1 / 2^{\prime \prime}$, four $2 \times 2 \times 1 / 2^{\prime \prime}$

Two additional large cubes are divided into quarters by two different cuts at right angles, one diagonally, the other from the mid point of each face.

The four $2 \times 2 \times 1 / 2$ " cuboids present the third division of the large cube by three cuts parallel to the face of the cube.

Cylinders: four of each, diameters 2 ", $1 \frac{1}{2}$ ", and $1^{\prime \prime}$, height $1 / 2$ ", 1 " and 2 " respectively.
Three cones, 2" in height, base 1" diameter.

Three pyramids, 2 " in height, base $1 \times 1 \times 1$ "
Total 54 blocks in a strong wooden box with a slide-in lid.

All the blocks are interrelated in a number of ways, can be broken down into fractions, and conversely, the blocks can be used to extend the series of cubes by construction of the 3 " cube.

$\mathbf{R}=\mathbf{R}=\mathbf{B}=\square$


Equivalences in volume of the G blocks.

$=\square \mathbf{R}+\mathbf{R}+\mathbf{B}$


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\end{aligned}
$$
\]

(or any other combination of these)

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Poleidoblocs A
Interrelations of the A blocks


## Contents

Cuboids: four of each, in lengths of $5^{\prime \prime}, 4^{\prime \prime}, 3^{\prime \prime}, 2^{\prime \prime}$ and $1^{\prime \prime}$ with cross section $1 \times 1^{\prime \prime}, 1 \times 1 / 2{ }^{\prime \prime}$ and $1 / 2 \times$ $1 / 2$ "; additional eight $1 \times 1 \times 1 / 2$ " and four $5 \times 2 \times 1 / 2$ ".

Right-angled triangles: eight of each with $21 / 2^{\prime \prime}, 2^{\prime \prime}, 1 \frac{1}{2 \prime}$ " and 1 " on the short sides, all $1 / 22^{\prime \prime}$ thick; additional 12 of the small triangles.

Cubes: twenty-four $1 / 2{ }^{\prime \prime}$ cubes (plus above mentioned $1 \times 1 \times 1$ ").

Total 140 blocks packed in a solid wooden box with slide-in lid.
The blocks of Poleidoblocs A can be used to construct the blocks of Poleidoblocs $G$ with the exception of the cylinders, cones and pyramids.

Besides the two boxes a number of regular and irregular Tetrahedra, relating to the $1 \frac{1}{2}{ }^{\prime \prime}$ cube of Poleidoblocs G can be supplied. Red 1" squares of plastic are supplied in polythene bags to be used for counting.


The variety of shapes and sizes in Poleidoblocs $G$ and $A$ enables children through construction and experiment to discover the basic structure of mathematics.

Poleidoblocs help the teacher to estimate each child's special abilities and rate of work. The range of shapes gives wide opportunities for discovering and establishing equivalences in length, height, area and volume.

The four rules can be applied to volume, area and length as well as to number so that work can move from one to another without causing confusion. And - POLEIDOBLOCS ARE FUN.

Equivalences in volume of the $1^{\prime \prime}$ cube shown in various positions.



## Foreword <br> by Margaret Lowenfeld, F.R.C. Psych.

Dr. Margaret Lowenfeld, who died $2^{\text {nd }}$ February 1973. This is the last manuscript written by my friend and colleague of the last twenty years. Ville Andersen.

A long time ago, after the first World War ended and before the cheerfulness of the thirties had developed, a printed leaflet appeared in the windows of the small shops in a poor quarter of N.W. London.

## CLINIC FOR NERVOUS AND DIFFICULT CHILDREN

12 Telford Road, Ladbroke Grove, W.10.
All children are difficult sometimes, some children are difficult all the time.
Some children seem always to be catching something and never to be quite well.
Some children are nervous and find life and school too difficult for them.
Some children have distressing habits.
This clinic, which is in charge of a physician, exists to help mothers in these kinds of troubles with their children, and also to help the children themselves.

Tuesday 10 a.m. Thursdays 2 p.m.
The purpose of the leaflet was to tell parents, teachers and anyone in the district interested in the welfare of children that a new Clinic had been opened in their district, and what kind of children the Clinic was designed to help. The physician mentioned was myself, and with me worked one of the Science Lecturers at a College of the London University.

All this took place in 1928, that is before the generosity of the Pilgrim Fund of the U.S.A. had begun to send trained workers and finance to Britain to introduce Child Guidance Clinics, so that at this time, apart from a small new Department for Mothers and Children which had begun work at the Tavistock clinic, no hospital or clinic of this kind existed in west London.

The district in which we worked was one where people of all kinds lived, mixed with a sprinkling of good artisans and families interested in their neighbourhood. The little shops which showed our leaflet were glad to help us and always took an interest in what was going on.

The children came eagerly - any child was allowed to come on his own if he wished to beginning with the 'bad boy of the area', who soon developed quickly into a lively and valuable youngster. Mothers began to find us out and want to talk to us. A valuable visitor,
the local Secretary of the Charity Organisation Society, soon came to call to see what we were doing and if there was something she could do to help.

My colleague and I welcomed her warmly and told her all about us, and what we wanted to accomplish. This lady negotiated with the L.C.C. and obtained the right for the children to get their school attendance mark for the time they were at our Clinic. She became our best friend in the district, as she knew everyone and was trusted by the authorities. Later she became for years the Chairman of our Executive Committee, and to her we owe the obtaining of permission from the Society of Friends to use an old Coaching Inn which they had turned into a Workpeople's Social Club in Clarendon Road called 'The Quest', to which our Clinic's work was moved in 1929.

At last it was possible to get down to the real aim of the Clinic's work. This had two aspects. On the one hand we wanted to provide a place within that neighbourhood where children from deprived homes, mothers and fathers unable to understand their children, could all find friends who cared about their difficulties and were ready to help. In this way as we gradually got to know the inhabitants of our district well, we could watch and see how far it was possible to bring the help that was needed, even to families and children with obstinate sociological difficulties that could not be removed. The second aspect united well with this, but in itself was entirely different.

What we set out to do was to find a building where there was space enough for children of all ages to run and jump and climb; to try themselves out in different ways, and above all to be helped by all of us to find ways in which their inmost thoughts, fears, worries and sorrows could be directly expressed; so that we - the adults who cared about them and could explain things to them - would be able to understand and to help.

The ground plan that I thought out for the work of the Clinic was designed to make possible research and experience along both these lines; but more closely and definitely along the second one.
'The Quest' had a large entry hall with a piano and we fortunately had a pianist among our group whom we used for dances and running games. Next to this was an open courtyard for ball games and also for quiet talks with staff.

Leading up from there was a staircase which gave on to a Waiting Room from which the Secretary's room opened. Inside another door opening from the landing was my Consulting Room, where I interviewed parents, and welcomed doctors who came to study our work, and visitors of all kinds. From this room a curly narrow iron staircase led down into the long Playroom, so that one could watch and slowly slip down to take part in what was going on below.

Meanwhile the upstairs Waiting Room gave opportunity for mothers to talk with each other and with members of the staff, and to learn gradually how to build a bridge of understanding to their children.

It was a hard working and a merry Centre, and outside the building the children climbed like ants over the waiting cars of the staff. But the real work went on in the Playroom and in the Physician's room where I sat, welcoming doctors, social workers, parents and teachers.

There is a photograph of the Playroom and the adults and children at work, in the brochure of the Institute of Child Psychology.

I use the term work deliberately because here was located our great adventure. This adventure stemmed from far away in Eastern Europe where, working as a Medical Officer in various Missions during the Russo-Polish war, I had learned from experience and seen it happen - that no loss of any kind, however drastic, could prevent 8-13 year old boys from growing into good and reliable adolescents if they could find a way to express themselves and their hopes and their sorrows, and skilled adults to listen and understand, to care for them and find bridges for them to cross over to adult life.

So in 'The Quest' we listened and watched, and bit by bit we saw that the children were devising new ways of expression, new ways of making clear to themselves the pictures and ideas that went on in their heads; revealing their hungers their dreams and fears; and realised that if we watched closely and asked them to talk to us as they did to each other, we could grow to understand them.

Slowly some techniques of expression such for example as 'The Lowenfeld Mosaic Test' (already invented by me) were developed making possible that what the children did with these techniques was carefully recorded by the adults working with them. We soon realised that as the children created ways to use them, these technical tools would 'talk back' to the children using them. Best among these tools was what the children themselves christened 'The World', some understanding of which has now been made possible by a book entitled The Lowenfeld World Technique written by Ruth Bowyer of Glasgow University Psychology Department, published by Pergamon.

Year by year the Clinic moved into larger and larger quarters, and in 1937 became the Institute of Child Psychology working at 6 Pembridge Villas, W. 11 (presented by a Trust and opened by the Minister of Education) for the treatment of children in need, and the training of Post-graduate men and women wishing to become child psychotherapists.

When the 1948 N.H.S. Act came into force, the fact that the property was freehold, prevented it from being taken over and 6 Pembridge Villas remains as the source of an increasing understanding of child development and of Techniques which allow children and trained adults to meet in sympathetic understanding. The Three Year Training Course steadily developed in authority and now draws students not only from Britain but also from far distant lands.

During the 1939-45 war the building was taken over by the Fire Service and the work evacuated to Berkhamsted. About eighteen months after return to London and resettlement in 6 Pembridge Villas I and two of my colleagues published a booklet from the I.C.P. called 'The Non-Verbal Thinking of Children' which set out the kernel of our discoveries about the non-verbal and so non-linear mode of thinking of children.

We know come to the reason for this Introduction to a book designed to help teachers to use materials which open doors into a new understanding of childrens' mathematical abilities.

Piaget had long ago taught us that children 'think in action', and I and my co-workers had also seen that often children think with their fingers; that they long to understand the object world they see around them, and to be able to use their own interior powers to work out solutions of problems that puzzle them. Somewhere here then, it should be possible to find a solution in concrete forms of mathematics. Not only are children able to express their imaginative ideas, but also piece by piece to increase their comprehension of the shapes and sizes of the furniture, the buildings, the day to day objects around them.

Here we need to pause a while, and think over why it is that 'school dropout', 'school phobia' and disturbances within schools are common features of today's life in most countries, and especially in our own, where these phenomena were rare before two world wars shook our social fabric.

In the days before the first World War and for a number of years after its conclusion, education, both primary and secondary whether national or traditional, i.e. local authority education or preparatory and public school, was geared to normal adult living whether as men and women workers in industry or as part of the organisation of the government of Britain and of the lands that came within the British Empire.

Some type of children it is true, especially those with their energies directed towards the open air, have always 'gone unwillingly to school'; but when what was taught in school related directly to ways of living and earning one's keep in the world of adult life, it was easy to see that giving one's attention to what was taught in school opened gates to employment in which one could do well on leaving school. It was clearly necessary then and sensible and within the child's own world, to work at understanding what was taught in school and in the end gaining formal certificates of education.

For that was the time when the organisation of adult life was stable. The World War being over, new wars did not break out in unexpected places; the moon was still silvery light to night expeditions and the threat of nuclear destruction seemed far away. That was - that is to say - before 1939 and the outbreak of a second World War.

Today on the contrary, wars seem to be breaking out everywhere - in S.E. Asia, in the East of the Mediterranean and even next door to our own island civil disturbances arise that greatly resemble war.

Meanwhile the ventures of the astronauts; new problems in civil living; new inter-country and inter-continental relations tend in our own country of Britain to obscure the highways between school achievement and success in adult life.

What is taught in school no longer seems to lead to definite tasks or achievements in the adult world. Youth today yearns for its own way of life; for the chance to develop new relationships and find new opportunities, or children begin to be bored in school.

Just as these trends began to appear it became clear to me that something had to be done. Children as we know them, we who work to help them to make bridges between home and school, and work later, needed help to stand on their own feet; feeling the life within them propelling them to activity.

If a child is to be genuinely educated, his personality has to be involved. Instruction of his intelligence only, is to leave the driving force of his personality untouched. One of these forces present in all undamaged children is the impulse to examine objects; to play with them, to arrange them in structures, study the effects, and enjoy them. Colour is essential for true enjoyment by small children, and colour is indeed a delight for children of all ages.

How could the facts we have now considered be combined with objects that could be used by children and by teachers, to satisfy this burning desire to understand? Little by little the mist surrounding this problem cleared, and the essential facts stood out. There are a limited number of true shapes in mathematics and these shapes are real. They can, of course, by drawn on paper or cut out in paper, but truest of all is their three-dimensional presentation. Why not begin with three-dimensional objects that can be picked up by children's fingers, felt and looked at, turned around and used to build with? Out of this sort of thinking came the germination of Poleidoblocs $G$.

Poleidoblocs $G$ is the name given to a set of 54 coloured blocks, very accurately cut, which present basic mathematical forms; cubes, squares, rectangular prisms, cylinders, cones and pyramids, each element so designed and cut as to be closely related to the other blocks in the set.

The central solid shape is a red $2^{\prime \prime}$ cube - four in a box. This is sectioned in three different ways, giving a series of rectangular prisms which relate to the section of the cube; one giving a set of four pillars 2" x 1" and coloured red; the second arising from corner to corner diagonal cuts and resulting in four triangular blocks 2 " in height $\times 2$ " with two short sides forming a right-angled shape coloured red; the third resulting from three cuts parallel to a face of the 2" cube, in four square prisms 2 " x $2^{" 1} 1 / 2$ coloured blue. Cylinders come next, the diameters fitting the side to side dimension of the different cubes; 2 " diameter $\times 1 / 2$ " high in red, $1 \frac{1}{2}$ " diameter x 1 " high in green and $1^{\prime \prime}$ diameter x $2^{\prime \prime}$ high in blue, and the blocks in the set make it possible for children to make two uses of them.

The first use (a) is called by us 'Free Construction' i.e. free experiment by the child with the full collection of blocks, to achieve expression of something he has seen around him and which he wants to create for himself. Use (b) is a different form of experiment, i.e. the discovery of the of the reversability of series and seriation; of equivalence; composition and decomposition - all of which underlie mathematical thinking.

Looked at this way, mathematics when expressed in Poleidoblocs $G$ should become for children an extension of the personal experience, and a new way of looking at objects and at the solid shapes they see all around them. Through imaginative handling, tactile and visual experimentation, these blocks create for children (even the small ones in the Primary arrival class) a basis for mathematical thinking, and provide at all stages, opportunity for pupils to devise concrete expression of symbolic statements.

Constructing with and thinking about these three sets of four identical blocks, children learn to understand the nature of a cube, so two other sets of cubes - four green cubes with $11 / 2^{\prime \prime}$ faces and eight blue 1" cubes; so a series is created.

Two quite different types of shape remain to be considered. These are three cones 2 " tall and coloured yellow, and three pyramids also 2 " tall with a 1 " square base and coloured yellow.

Children often ask why, when there are four of all the other shaped blocks, there are only three of these two rather exciting strange new shapes. When they are old enough and far enough advanced in their mathematical understanding, the explanation should be given that although the yellow cone fits, on top of the blue cylinder and makes a splendid spire, yet if the cylinder were to be moulded out of plasticine and three cones also moulded at the same time, the same amount of plasticine would be needed for each - the one cylinder and the three cones.

Furthermore, the same thing is true for the three pyramids which fit on top of the red pillars or stand on three blue 2" cubes; and this is because cylinders are made of three cones and rectangular pillars of the same amount of material as three pyramids, and later they will come to know how this comes about.

Expressions of area follow - all geared to fit with the cubes and their sections and the cylinders. First a 6 " x $2^{\prime \prime} \times 1 / 2{ }^{1 / 2}$ set of four blocks coloured yellow; then four green blocks 4 " x $2^{\prime \prime} \times 1 / 2$ " and to complete the series four square prisms of the blue sections of the 2 " cube, each 2 " $\times 2^{\prime \prime} \times 1 / 2$ " covering the face of the yellow blocks.

Poleidoblocs A in plain-coloured fine-grained wood, add to the three dimensional varieties of concrete mathematical fact, giving seriation in length, area, number and shape; enabling users to recognise these principles in the outer world; to foresee them and to use them for further discoveries.

Having thought a while about how Poleidoblocs appear to children, it is time to give thought to the teacher.

## For the teacher

Several factors are important - let us list these and think about them. For adults used to mathematics carried out with figures and specialised symbols, it is not easy to acquire an immediate grasp of Poleidoblocs, either G or A . Even architects whose work is very competent on the drawing board, now and then find it difficult to see in their mind's eye the three dimensional version of what they have drawn. The same is true of mathematics.

Teachers planning to use Poleidoblocs with their children should start by giving themselves the pleasure of seeing how all the blocks in one box, when spilled in a heap on a table, appear to imagination, and what kind of constructions they can make out of them.

When starting to use Poleidoblocs with children, certain points are important.
a. The blocks should be put in a loose heap on the table at which the child or children are going to work, and the box TAKEN AWAY.
b. Putting the blocks back neatly in the box should be reserved as a special privilege for the child whose work shows most imagination or clear understanding.
c. The diagram which covers the base of the box enables the child to grasp the actual dimensions of the individual blocks.

## d. ONLY ONE BOX OF BLOCKS SHOULD BE USED AT A TIME.

In Section (I) by Miss Andersen, will be found a report of our experience of children, Poleidoblocs and the relation of the Poleidoblocs table in the background of the schoolroom to ordinary school work. Quite apart from the process of mathematical teaching, Poleidoblocs in themselves contain new and valuable aids to teachers in understanding their children - for example:

1. Where Poleidoblocs are used in Free Construction, what the children do with them make it possible -
a. On a child's entry into school to assess the stage of development of recognition of shape and size the child has reached, and to provide the experiences needed for further growth. b. At all stages to distinguish between different types and temperaments of children, and different modes of spontaneous thinking.
2. When used as Teaching material they make it possible to adjust the rate of work to the comprehension of the children and to test at each stage, the extent to which real understanding of principle or a procedure has been achieved by each child. Only careful experimentation by teachers in order to gain familiarity with component blocks of $G$ and $A$ can open out for them a view of the potentials latent in this material.

When Poleidoblocs are established in a school and children have become used to looking forward to their opportunities to work with them, does it become possible to observe the vigour, interest, imaginative excitement and concentration which children of even 5/6 years give to their work with these blocks.

In this last sentence there is a crucial and important word - it is WORK - since one essential quality of Poleidoblocs, whether G or $A$, is that children, once they have discovered the variety of possibilities and the interesting constructions that these blocks afford, there arises in them a genuine delight in working with them and thinking about what they have produced.

So the keyword for children and Poleidoblocs is enjoyment of WORK with them.
Let us therefore look at Poleidoblocs as a whole, and consider the underlying principles that have guided me in their constructions, and the aims with which they have been designed.

1. In designing Poleidoblocs I set out to provide tools which in themselves express mathematical relations of area, volume, number, series and types of progression, up to a quite advanced level.
2. To make it possible for children in the Infants' sections of Primary schools or in the Secondary division to build up factual experience of the basic principles from which mathematics arise, viz. reversability, equivalences, series and seriation, composition and decomposition and conservation, gaining therewith factual experience paralleling Piaget's demonstrations of these concepts.
3. To make it possible for children to discover for themselves the interchangeability of area, volume and number, so that they can find out by themselves that volume does not depend on shape, but that although the three different modes in which the Poleidoblocs G red 2" cubes are sectioned, look quite different, nevertheless when four of each shape are put together they recreate the 2 " cube.
4. To enable pupils to acquire an understanding of the unity which underlies different aspects of mathematical thought, such as algebra, arithmetic and geometry, which only too easily come to be regarded by the children as entirely separate subjects.
5. When the use of Poleidoblocs in a class has been extended from Poleidoblocs G to Poleidoblocs A, then the place of pattern and orientation of patterns become a subject of great interest and concern, forming little by little, a bridge to geometry and algebra.

Practicing teachers will find that Poleidoblocs have assistance to give them as teachers in several very important directions.
A. They have a diagnostic quality in that careful observations of the individual children's work through three experiments in Free Construction, will enable a teacher to make a swift contact with the child, observing the main characteristic of both what he or she has constructed and his or her attitude to it. In this way a comprehension of the main characteristics of each child can be gathered in the first term of work with them, instead of having to wait until the end of the school year.
B. A teacher watching the week to week work of their children with Poleidoblocs will find it easy to note which are the slow children, who although working all the time, only slowly achieve what they are endeavouring to construct, proceeding at a much slower rate than the quick versatile children.

A teacher who has read as far as this may well feel that useful though all that is described about the teacher's side of work with Poleidoblocs is, yet this would be difficult and complicated to carry out.

When Miss Andersen and I first worked together with teachers, this view struck us also as a possible first reaction to problems in the use of Poleidoblocs. But here Miss Andersen's skill in the making of a sound and Practical Record Form comes in, where little is asked of the teacher beyond ticking off varieties of construction drawn from the day to day experience with children and Poleidoblocs. This very largely solves the problem of observation and memory.

Earlier in this introduction I stressed the fact that the process of education should include the personality as well as the intellect and imagination of a child. In these days of unrest, this point is of very special importance and it is our experience that the school and the staff of teachers have a new and positive part to play in bringing about a sound process of development in the children attending the school, if they give serious attention to the children's use of Poleidoblocs.

This may sound peculiar, but indeed is very true, because in their struggle with their own lack of knowledge, with the limited number of shapes and repetition of individual shapes a
child finds himself up against frustration; there are not, for instance enough 2" cubes for him to make the splendid tower at which he aims - what is he to do?

This is a true difficulty; a normal situation in creative action; will the child borrow from his neighbour? give up his attempt? content himself with a different goal? lose his temper and smash what he has already done? It is a true difficulty - a piece of real life.

Then again, when children see something in their imagination and eagerly set out to put their vision into action, they meet afresh the basic hindrances offered by fixed objects to creative initiative. What can he now do? As the teacher finds time to watch evidence of a child's distress she will see how the child feels, and can explain how useful it is to struggle even when a dream must be given up and something simple and humdrum accepted instead.

It is this quality of reality about the spontaneity, the effort of thought and imagination - the inevitable and wholesome choices that have to be made, which make a direct impact upon the personalities of the children at work on Free Construction, and provides for them a bridge into the fundamental experiences of real living in a real world.

The impact of Poleidoblocs on a school is not confined to mathematics. It is the initiation of the children, even the very young, into the life of effort and joy in effort, and in the excitement of actual gaining of their goals.

In this life where so much goes wrong; which is full of disappointments, jars and discoveries of one's own limitations, mathematics stand as truth: truth which cannot be gainsaid, but which is as true for Dad and Mum as for the child in school.

To have a part of school life where truth can be found if sought, is to give to the children a width of outlook which energises mind and heart and the quivering urge to creative manipulation, so that frustration becomes tolerated and fresh effort made, so an inheritance is given to the child which he or she will carry within them in the end, out into the adult life.

Let us be glad therefore that we can share with our children this excitement and this discipline, and watch the growing belief in themselves as together they build Dad's garage, or a cathedral, or an astronaut's rocket, or a new and lovely kitchen for Mum or a special place to go swimming in the summer. Children who can learn to tolerate frustration in school and to return again with high heart to their effort, become young adults who can do the same in life. It is these young adults who will in the normal passage of time build the environment in which human beings can live that life that healthy adults ought to live.


## Poleidoblocs: How to Begin <br> By Ville Andersen, D.I.C.P.

The first boxes of Poleidoblocs $G$ and $A$ were available for purchase from the beginning of 1958, and then only a small quantity. They were mostly acquired by Universities for research purposes in Great Britain and the U.S.A. and by Child Guidance Clinics. But from 1959 they began to find their way into British schools, teachers having in one way or another, often by chance, come to hear of their existence and wishing to try them out in their schools.

From 1968 Poleidoblocs were purchased and distributed over a large area of Great Britain, from Edinburgh to Sussex, from Essex to Bristol and Cheltenham. On several occasions we were asked to send samples of the boxes with display instructions to teachers' study group meetings and on a few occasions we were asked to come and demonstrate the Poleidoblocs ourselves.

There were at that time no specific instructions as to the use of Poleidoblocs. Each purchaser experimented with them in his own way and for his own purpose, whether in research or teaching. When the grant from the British Association for the Advancement of Science was given at the end of 1960 for a two year period to introduce the material into British schools, it became necessary to work out a specific standard way of introducing the blocks to children and also a way of recording what was done, for later comparison and discussion.

Until then we had used them ourselves only in the therapeutic setting at the Institute of Child Psychology, that is to say - one adult with one child, the therapist watching what the child was doing and discussing it with him. The child had free use of the material, could make whatever he wished, could discuss his construction with his therapist and its various points could be made clear to him. Also the child could get help and advice if he was faced with a problem he could not solve himself.

From this, to introducing the material into a school setting with up to 40 children in one class, and with only one teacher available, called for quite a lot of thinking and planning.

As the investigation of the use of Poleidoblocs in British schools, sponsored by the British Association, was to take place in Leicestershire, it was a great help to be taken round to several schools in this county by the County Educational Schools Adviser for some days, and to be permitted to sit and watch in various classes how a day at school went for the children and their teachers. What was needed was to find a way and a time during school hours which would give the child an opportunity to work with the blocks as freely as possible, and to make his own experiments with them without interference or direction from the teacher. The main aim was that each child in school should have the same opportunity as far as possible, as a child in a clinical setting to become familiar with the blocks, their sizes, shapes and colours (G box) and their interrelation, by what we then chose to use as a technical term "Free Construction" periods in the ordinary school setting.

It was of course not possible to isolate each child for a certain period with his teacher's full attention to what he did. But as we knew from years of personal experience with

Poleidoblocs that the material itself evoked a certain fascination in children, so they often spontaneously asked for it, we felt it would be sufficient to organise periods during school hours for each child to occupy himself with the blocks and to make with them what he liked. Then he should have an opportunity to tell his teacher about his construction (s) and perhaps ask questions.

We had to find a way to achieve this, and it could only be done by trial and error.
As the classes were pretty full and the teachers very busy, we did not venture to suggest that the children should work individually, as it would have taken too much time to get through a class of children and to collect evidence of how they accepted this new tool. So we suggested that the children worked in groups of four to six at a time, seated round a large table (composed of smaller tables put together) but so that each child could easily reach the blocks. The contents of two boxes of Poleidoblocs $G$ were then disposed in a casual way in the middle of the table, and the boxes removed. The group should preferably consist of boys and girls, should be altered in composition when the next turn came, so that no group should be dominated by an individual child.

Each child should, if possible, have the opportunity to work with the blocks once a week. This we found later was too often, so the intervals between Free Construction periods were made longer. It also had to fit into the teacher's work with the rest of the class, so he or she could spare as much time as possible observing the children at work, and talk with them afterwards about what they had been doing.

All children should begin with the G blocks and the A blocks should not be used in Infants' classes, as there are too many pieces, some very small, for the young child to cope with, and it might confuse the childrens' grasp of the interrelationship of the blocks. In Junior schools, however, where the teacher would want to use the material for teaching purposes as soon as possible, we considered it sufficient for each child to make first three Free Constructions with the $G$ blocks, followed by three with the A blocks, and then preferably each child working individually by himself.

The introduction of Poleidoblocs to the class is very important, and a standard formula was suggested and should always be applied.

The teacher should first show the box to the whole class, remove the lid and tilt the box so that the contents can be seen, pointing out the nice pattern the pieces make when put in their proper places in the box. Now is the time to tell the children a story about the contents, that calls their attention into focus. We have all met a child's love for a small stone or pebble. He may be attracted by its colour, its shape or the smooth feel when touching it, and many children guard their treasures fiercely.

It is this feeling of 'specialness' which should be created for the children in relation to Poleidoblocs. These are not just ordinary building bricks, they are special, they have been specially made to work with in schools.

Having introduced the blocks they should be taken out one by one in irregular order, only one of a kind at a time, while the teacher explains that they are rather like a family, as some have common qualities such as colour or shape and some not, and there are interesting
things to be found out about them. This 'finding out' is what work with Poleidoblocs is going to do.

At some point here, the teacher removes all the blocks from the box to show the diagram on the base and points out that the presence of this diagram makes it sure that all the blocks return safely to the box again in their correct places.

The teacher then places them all back in the box, to show they go neatly home, and shows the full box so that the children see the arrangement again.

It is then up to the teacher to choose when the Free Construction periods could best be fitted in during the work and each child in turn given the opportunity to work with them.

We decided that a standard, not suggestive phrase should be made by the teacher when the children were ready to begin, such as - 'Make with the blocks whatever you like - and tell me when you have finished', leaving the child to get on by himself.

We found early on, that it was important that the teacher used the word 'work' not 'play' when calling the children to their Free Construction sessions. Again, it was the children who taught us, as once an Infant school teacher happened to say to a group of youngsters in her class 'Now it is your turn to play with the blocks' and immediately got the reply 'We don't want to play, we want to work!' The teacher was quick to take the hint and replied 'Let's sit down and see what we can find out about these blocks' and the children went to work and found how many small ones made up the big ones, etc. A child in his first years of school has, of course, in his own opinion of himself, left 'playthings' behind when at school. He wants to work and to find out and to learn.

In order that we could get an idea of the childrens' attitude to this material and the use they made of it, a Record Form was designed to be filled in by the teacher after or during each Free Construction period. This also made it possible for the teachers themselves to compare by the end of, say a term, what actually each child's responses had been. As we knew the teachers had very little time to spare, the Record Form was designed so that most questions could be answered by a tick in the relevant column, and only the name and explanation the child gave of his construction, spontaneous remarks and any special observations made by the teacher needed to be written in words.

As this first experiment was arranged so that a group of children worked at the same time (not necessarily working together, which did not actually happen very often) the Record Form had space for the names of up to six children. It made it easy for the teacher and us to see which child made something original on his own, had his own ideas, or who copied somebody else, if not actually the construction made, but by identical names they gave it. As for instance, when out of six children's responses three call their a 'Japanese fort' there can be no doubt of copying names. But in order to get an idea of a single child's consecutive constructions, it was necessary to separate them out from each Record Form.

During this period several visits were made to the four schools taking part in the investigation, giving the opportunity to see how it all worked, and to discuss matters with the headmasters and the teachers. There were matters to be clarified, instructions to be
modified, and we shared the progress made with the schools who had undertaken considerable extra work on top of an already busy schoolday.

The time limit was to be around 20 minutes, but if a child had been some time getting started or was in the process of finishing, he should be allowed more time. Most children finished however, in less than the time given and those few who got nothing completed, would not have achieved anything by extending the time.

As each child finished, the teacher's task was to find out what the child had intended to make, and to suggest the child should 'tell her about it', avoiding leading questions. Some children might not have thought of anything special but if they heard the others name their constructions they may think it necessary to say something, and then they plump for one or other name already given, as mentioned above. There the teacher can assist by saying first something praising about the response and then casually ask is it meant to be something special?' The more time the teacher can spare to discuss the construction with the child, the more she will get to know about this child's individual way of 'thinking with objects', his ideas, his imagination. It will also give the teacher the opportunity to point out special features in the construction that the child has not been aware of while making it, and in this way, lay the foundation for the child's perception of similarities, equality, balance, symmetry etc.

As my task was to introduce the first steps of the use of Poleidoblocs in schools, the question of how and when to use the material for actual teaching was left to the individual teacher. However, every child's first experience with Poleidoblocs should always be some Free Construction sessions, first with the G's and then with the A's, according to the child's age and ability.

It was also important that this should take place in the classroom and the child not separated from his classmates, for instance left in a room by himself, as this might give him a feeling of isolation which was not intended. A child has an enormous capacity for concentration when his attention is caught and held, and even if some other child passing his table, should pause and make a suggestion, it will not be taken if not in line with the worker's own thought. And as work with Poleidoblocs becomes 'something we all do at school' the children at work will not be interfered with by the rest of the class.

There were as well pros and cons for having the children working in groups during the first terms in the Leicestershire infant schools. As could be expected, when they were seated round the table with the blocks in a heap in the middle, and the teacher said they could begin, each child would plunge forward and grasp as many as he could, regardless of what he got. The strong child got most, the slow and shy child only a few, and it was difficult to insist on a rule that they only took one block at a time as they needed them. But it had the advantage that they had to make do with what each had been able to get hold of, and sometimes that led to swapping pieces - 'Can I have your yellow one for one of my green?'

It called for competition and comparison - who's tower is the highest, how can we measure it? For instance -

Tony and Peter built towers. Tony said his was the highest; he measured his by standing up. Peter also stood up, he said he was as high as Tony and his tower was higher than Tony's. Tony then tried to build his higher. Or - Chris and Fay built towers and Chris said they were both the same; they discussed this and yellow slats were used to prove who was right. Chris' was slightly taller.

Also collective 'finding out' came naturally. One child started counting his blocks and the others started counting theirs. Once they found out that the highest tower did not have the most blocks. Sometimes two children would make a combined response -

Andrew and William built their constructions and joined them together with 'a magic path'.

Only once in the Record Forms examined did all six children make a group response - a yard containing sheds, a house, a well, flower beds and walled gardens. In this case there must have been a definite leader among them.

For the timid and insecure child and the one with little or no imagination there was security in the group, seeing that all the others 'did' something with their blocks, so if sometimes nothing was actually completed, the child had the opportunity of handling the blocks and perhaps next time he would actually be able to do something himself.

The group children also discussed with the others what they were doing and called attention to their work. Of the responses examined only four ( 3 boys and 1 girl) of a total of 490 responses were reported to be silent while working.

But even if a total of 108 blocks (the contents of two $G$ boxes) were to be shared by six children, giving them a fair amount each, what each child made with them might not be what he could have made with the contents of one box to himself. Also the influence of what the rest of the group made could not be entirely eliminated. It showed his response to a restricted number of blocks, perhaps not the ones he would have chosen, but also how he reacted to suggestions, competition and sharing while working with the others.

It was therefore decided that during the last part of the investigation in Leicestershire, the children should work individually, each at a table by himself, two at a time, and each have the contents of one $G$ box to work with. The same Record Forms were used, but the teacher indicated on the Form which two children were working at the same time.

When in 1966 a group of schools under the Harlow Mathematic Study Group ventured into making an investigation of the use of Poleidoblocs in their schools, the Record Form used in Leicestershire was revised and redesigned so that each child had his own Record Form with room for six responses. The children were to work individually from the start and the six responses were to be spaced within one school year. The same procedure of introducing the material to the class as described on page 3 was maintained, also the administration of the material to the single child. This was made into a short introduction for the teachers use with comments on how to use the Records Forms.

When the Harlow experiment was over, it was again time to revise the Record Form and simplify the Instructions for future use. They will be produced here as App $X$ and $Y$. The aim
had been to avoid ambiguous items (such as whether a construction was asymmetrical or amorphous) and to list only what would apply to any child's response and easy for the teacher to assess and fill in. Following are examples and commentaries on the various points.

## Attitude

At the beginning of the session they may be eager, indifferent, bored or just refuse. Their remarks may vary from 'this is just smashing' or 'I can't do anything, they are just blocks'. Most children however, do get going, sometimes when hesitating, encouraged by others in the class. If there is a flat, persistent refusal from any child, this should be accepted by the teacher and recorded on the Form. He may do something next time - it depends on the reason for refusal - if timid or insecure, give him time - if lack of interest, don't press him.

At the end of the session they may be indifferent whether to stop or not. Most children finish a construction started, and the child who makes a complicated structure should have the time needed to finish it. On the other hand, if some child makes constructions one after another, not because he is endeavouring to find something he is satisfied with, but only building up, taking to pieces and repeating this, then he should be stopped. The teacher might in this case, ask him if he is trying to find out something, perhaps he would like to discuss it.

## Compare shape and size

Many children comment on the nice colours, how smooth the blocks are to touch. It was a surprise to find from the Record Forms examined that the majority of children took notice from the beginning of the different sizes and shapes, and arranged them in some order before they began working.

## Type of construction

Here the overall shape is decisive. All constructions will naturally have to be of some height when made on a table, even a well which is thought to go 'down'. A castle can be built in height, but it can also be a castle with smaller buildings and towers connected by walls; then it would be 'in width'. Bridges, tunnels and trains will naturally be classed as 'in width' while several smaller constructions dispersed on the table, or moving traffic, will belong under the heading 'spread out' whether they are part of a whole town, village, playground etc. or considered by the child as single objects.

Most children build in height, even girls; in width or spread out it is almost equal. We were at first not aware of the variant 'enclosures', but a teacher commented that many girls called their response 'a house' while actually it was an enclosure with objects inside it. It is therefore included in the revised Record Form. Some, but not many children move their cars or trains about, so this was not included in the final Form but can be noted on the back of it if the teacher finds it important.

The final point under this heading is 'experimenting' and only the teacher can judge whether the child is really experimenting or making several attempts to achieve something. It may be that the measure of concentration can give the clue.

## Final results

Most children complete their constructions whether working individually or in groups; nearly all group children did (98\%) leaving only a small percentage with 'nothing completed'. It is seeing what the others can do that encourages the hesitant and uncertain child to make something also. Even when a child working by himself cannot get started, it is encouraging to note how concerned his classmates may be about it. One teacher reports how one or other of them stopped at a girl's table, told her how nice the blocks were and tried to show what could be done. If such a child, does not get started, it is better that the teacher postpones the session until another time; otherwise the child may get deeper and deeper in his misery over not being able to make something. Poleidoblocs must never be felt by the children as something beyond their power to cope with. Some tell stories in relation to their constructions, the individuals more than the group children, but that may be because the individual child has more time to tell the teacher about it, and the teacher more time to listen. Such stories could be recorded on the back of the Form.

Nearly all children give their construction a name. It might be something the child set out to make from the beginning or something that takes shape while fitting the blocks together, or rearranging them; or he may name it after what it looks like to him when finished. The completed but not named constructions are few among the individuals (hardly existing among group children). On one occasion a small boy boldly stated 'I don't know what it is but I like it'. This must be a very independent and self-possessed secure child because most of them have a feeling that it has to be something. The teacher should be careful not to convey any such idea when asking the child about it, and it is really not important whether a child can give his construction a name or not; it is the way in which he has used the blocks, how much he has been aware of the interrelation of them, in which way he has been able to substitute or reconstruct a bigger piece with smaller ones if a particular shape was not available and he wanted to achieve balance or symmetry. This is his 'thinking with objects'; the name he eventually gives it will be the idea he has in his mind, reflecting his sphere of interest and his imagination, and that will be dealt with in the following paragraph.

Sometimes the unexpected happens. A boy of $61 / 2$, well adjusted, said to be keen on maths and with a keen sense of humour, when confronted with Poleidoblocs in his first Free Construction period, made many small structures and discarded them; on his second session he 'just sat and stared at the blocks jumbled in front of him' according to his teacher.

This boy may have developed ahead of his chronological age or be somewhat inhibited with the experimentation of objects; he has little imagination; he may come from a background with strong emphasis on the necessity and importance of learning. At a later date the need for what he missed earlier may appear, and it may be wise for the teacher to watch for it. Such cases are quite common in psychotherapy.

When a structure is named by the child, it falls into the category Representational with five sub-groups.

Only a relatively small proportion come under the heading Objects, which means single objects not included in any other group and not related to each other as for instance, a car and a garage would be. Yet there were some unusual items among them, such as: a dustbin,
a crab, a mousetrap, daddy's tool box, a candle, toadstools, besides the more usual such as record players, slides, roundabouts, toys, machines etc. Some girls made 'patterns' of the shapes or the colours, and it is regrettable that there were not means available for photo recording.

External scenes is far the largest sub-group, with 94\% of the group children (1961) and 62\% of the individual responses (1967). If this sub-group is further analysed into categories of Environment, Places visited or heard of, Traffic, Outer Space, we find some interesting difference in boys' and girls' responses in the 1967 Record Forms. If under the heading Environment we count all the items which at the present day will be part of a child's everyday surroundings, we find that they represent $60 \%$ of the girls' responses, but only $26 \%$ of the boys' responses. It looks therefore as if the 5-6 year old girl is much more aware of her daily surroundings than the same age group boy. Of these, 'houses' is the most frequent item on the girls' responses; often she builds only the actual rooms with furniture, people etc. and calls this 'a house', while the boys build very few houses, and then it is the actual building. But not only houses are important for the girls, also the town itself or the village with church, shops, school, people, gardens and parks. Also entertainment is included with cinemas, shows and fairs. Boys think more in terms of factories, parking, power and radio stations. On the other hand, it was a girl who built a football stadium and a boy who made a wedding reception.

One favourite feature for building for boys as well as girls are churches; perhaps because the old churches in Britain are impressive buildings, even in small villages, and here church and school are often situated side by side, so a church becomes a natural part of the environment. A girl makes a 'burnt down church', a boy adds to his church 'a place where they go for tea; but most remarkable is the small boy who makes 'a church on wheels so it can go to the rescue'. It is a reminder to us of how children think in facts: 'churches' come to the rescue of people in need all over the world, and how should they be able to go there if not on wheels?

If 'Places visited or heard of' are considered, castles and palaces are favourites, but also the sights of London (from school excursions, perhaps) appear in the responses, even museums. The boys make forts, the girls make mazes, one of which is 'secret'.

In terms of Traffic the boys' responses outnumber those of the girls, especially as far as air traffic is concerned. This is also the case, even more marked, when the responses relate to Outer Space. The girls here show very little interest or imagination and build only rocket stations, while the boys' responses are varied and real. They will of course, have had opportunity to watch much of it on T.V. but three small boys have really thought ahead, and their imagined future development deserves to be recorded: -

One makes a 'Space bulldozer with Instruction Tower'. A bulldozer is a machine which removes obstacles, and the maker imagines there will be obstacles in Outer Space that have to be removed, therefore a bulldozer may be needed with its instruction tower.

Another boy makes 'Two planets with a roadway between'. What he means is a communication line between two planets, but not knowing the abstract word 'communication' he calls it a roadway.

A third boy makes a 'Space Control Engine' which needs no interpretation.
They were after all only six years old, the first said to be very intelligent with a remarkable fund of information, but the second boy a foster child, very difficult and disturbed, who cries easily.

It is also a boy who adds the new feature: oil, by making an 'Oil station with Oil tower.'
The examples given above have been recorded from the 1967 'individual' responses, but when we look back on the 'group' responses from 1961 we also find objects concerning Space, but at that time only in terms of rockets, mostly unrealistic such as farms with rockets, garages with rockets, rockets with bricks; some girls even make 'rockets with toilets'.

Children's imagination and actual knowledge about new inventions and new adventures will naturally be accelerated in relation to the development of communication, such as T.V. and space satellites and what may come in the future.

Interior scenes, some with people and animals, are also more frequent in girls' than in boys' responses. There are people in houses, castles, towns, walking across a bridge, school with teacher and children. There are animals in Zoos and horses in stables. One girl makes what she calls 'Mummy writing' - unfortunately we have no photo of it, because it is difficult for us grown-ups to imagine how a child sees this represented with the blocks. The sub-group Phantasy is poorly represented. Everyday life offers so much that is real to feed children's imagination that the old fairy tales disappear; only the witch seems to have survived, some features from modern fiction are also represented. But as modern fiction is mostly visually represented in comic strips in magazines or audio/visually on T.V. they do not challenge the child's own inner imaginative 'picture-making' as did the old fairy tales. In my opinion this is to be deplored.

If we summarise the responses to the group Representational made by the 5-6 year old children from the Harlow experiment and compare boys' and girls' responses we find the following: -

| Categories | Boys | Girls |
| :--- | :--- | :--- |
| Environment | $26 \%$ | $60 \%$ |
| Places visited or heard of | $38 \%$ | $29 \%$ |
| Traffic | $13 \%$ | $4 \%$ |
| Space, present day \& future | $16 \%$ | $1 \%$ |


| Fiction, Fairy tale | $3 \%$ | $2 \%$ |
| :--- | :--- | :--- |
| Miscellaneous | $3 \%$ | $5 \%$ |

The question of Symmetry is interesting, but as the Harlow Record Form was not clearly enough formulated, and the item was not included in the Leicestershire Record Form, the revised Record Form (see App X) contains only one item to be ticked if applied to the construction in question, otherwise not. The most interesting occasion in relation to symmetry was once when I attended a session in a Leicestershire Infant school: a small boy selected identical blocks with both hands and placed them simultaneously on a symmetrical construction. It may be of general interest if teachers made special notes of similar behaviour. Another question in relation to symmetry is that of balance, as we have seen in responses to the Lowenfeld Mosaic Test. A feeling for balance is related to a feeling for symmetry, but less rigid in many ways. Such cases can be recorded on the back of the Form.

Teacher's Estimate of the child's response as applied to the actual construction can be classified in one of four categories: brilliant, good, average or poor execution. This can of course mostly be of use for the teacher who wants to follow the single child's responses through a series of Free Construction sessions as no rule can be given as to what can be classified in these categories. The judgement must in every case be a subjective valuation by the individual teacher.

Finally, the children were asked their own opinion of what they had made in terms of "satisfied" or "not satisfied". In the 'individual' responses (Harlow 1967) far the greatest part was satisfied with what they had achieved. The girls were generally more satisfied (in terms of percentage) than the boys. Comparing this with the 'group' responses (Leicestershire 1961) we find that only half of the children said they were satisfied with their achievement, boys and girls nearly the same. In this case one cannot rule out the question of copying answers. If the first child asked says No, and no comment to this given by the teacher (which is correct) some insecure children may well think this is what is right to say, so they will also say No. In the 'individual' cases the child has only his own opinion to give, and in most cases they like what they have done.

We would like to stress that the experiments in Leicestershire and in Harlow have been investigations and not research in the scientific meaning of this word. Our main aim was to gain experience of what was possible and what responses could be got under the circumstances available. It was not the main purpose to find out, for instance, how many children built in height, in width etc., or what kind of construction was made in each category. The main purpose was first to find how children reacted to Free Construction periods in a school setting, and if it was possible to fit it into an ordinary school schedule. Secondly, by recording not only the childrens' general attitude and response to Poleidoblocs, but also what they made and what they said their constructions were meant to be, it has also been possible to classify these responses into general and specific categories for later comparison. The comments and the results dealt with in this chapter are based on an analysis of the Record Forms, filled in by the teachers. The answers to our queries have been that the children's attitude on the whole has been positive, their
responses interesting and the interested teachers have found ways and means of fitting Free Construction periods into the time schedule of their classes.

What has been achieved by these Free Construction periods for the single child and for the class as a whole can best be judged by the teacher, so - over to the teachers in the following chapter.


How to continue
By Mrs Marjorie Smith and Mr G Thornhill

## Introduction to the class

Before introducing Poleidoblocs to children teachers should, and must, experiment with the material themselves, both in the form of free construction and then in the more directed teaching aspects. To really get the 'feel' of the blocks, and to discover their potential richness for mathematical worth is of profound importance.

Although Poleidoblocs are essentially aids to the teaching of mathematics, there is far more to them than that, and we should be aware of this. Appreciating the fact that young children exercise their senses continually and have a natural curiosity for their environment, then their desire for exploring, touching and manipulating must be met. Smell, colour, shape and face are all exciting features which must find expression through suitable activities. To create and experiment, therefore, are vital psychological needs - these start in their play at home, and so must be recognised factors when helping them to adapt to the increasing demands of the school. If this transition is intelligently handled then the children obviously adjust more readily to a formalised learning situation to society generally, and to their teachers in particular.

The observant teacher can, undoubtedly, learn a great deal about the children she teaches when watching them work with Poleidoblocs. For example, their response to others with whom they are working, the way in which they construct, those who are out-going, those who are not, in fact, all these inherent differences which, if known about and used wisely, help the developing personalities of children to find a worthwhile richness and enjoyment in school life.

To give ample scope to all the creative needs it is necessary to give ample time to free construction. Miss Ville Andersen gives full instructions on how to introduce this aspect of her work in her chapter 'How to Begin'. The obvious enjoyment derived by children during these periods is clearly apparent but even more apparent is the purposefulness of the learning situation. So much mathematical knowledge is gained, quite spontaneously, that for young children of Infant age it is sufficient experience in itself. When children have fully familiarised themselves with the blocks it is remarkable to observe how adventurous and exciting many of their structures become.

Later work with Juniors has convinced us that the inter-action between directed study and free construction is desirable. There must be a balance between formalised teaching and experimentation of a creative, uninhibited kind.

Poleidoblocs are powerful aids to the teaching of mathematical concepts, if used wisely by enlightened teachers who have studied them, and experimented with them beforehand. They have their limitations, as all types of structured apparatus have, nevertheless, Poleidoblocs have a flexibility which no other kind of mathematical apparatus offers.


## 1. Free construction

A series of 'free construction' periods is of primary importance before any actual teaching aspects are introduced. This point has been made clear in Miss Ville Andersen's section, 'How to Begin'. The children need time to acquaint themselves with the blocks and experiment with them.

When working with children between the ages of 5 and 9 years, the ' $G$ ' blocks are more advantageous and meet their mathematical needs, generally speaking. But, with children between 9 and 13 years of age the ' $A$ ' blocks prove to be far more stimulating and challenging. It should be made clear though that at least six sessions with the ' $G$ ' blocks are necessary and extremely beneficial.

The coloured ' $G$ ' blocks have a strong appeal since their colours, shape and feel have special aesthetic qualities which are very satisfying, especially in the early approach stages. We suggest that children should not use the material more than twice a week, and that each session should last for about twenty minutes only. In this way most children will look forward to working with the blocks and almost all will have completed a construction within the suggested time.

Ample space should be provided in the way of large table top surfaces, or, as any good teacher knows, the floor! Because of the child's desire for a variety of shapes, and of sufficient quantity, no more than two should be expected to share a box of Poleidoblocs. Remember to remove the box itself after the blocks have been removed for reasons already outlined by Miss Andersen in her chapter, 'How to Begin'. In some cases you will find a one to one correspondence (one box to one child) necessary, for obvious reasons of personality; for example some children prefer to construct alone. One learns a great deal about children when observing situations of co-operation - or perhaps non-co-operation! One of a pair will sometimes dominate the other, whilst others help each other in the best sense of the word. All these possibilities will undoubtedly be noticed by experienced observant teachers, who know only too well how useful such information can be.

Temptation to take up, and discuss, teaching aspects of the work at this stage should be resisted at all costs. Emphasis is better placed on the recording of observations, namely the types of construction. For example, those built in the perpendicular, horizontal or a mixture of both. The child will often tell you what his building is, i.e. a space station, a bridge with boats, a castle etc., and the more one looks at these, the more interesting they become.

Freedom to experiment in a variety of situations is of profound importance to the child if his needs, within the scope of the material, are to be met. The philosophy of this approach should become more apparent in the next chapter.

Finally, it might be of value to note that we have found that the vast majority of children do not like mixing blocks of ' $G$ ' and ' $A$ ', they much prefer to use one or the other. Only when very experienced will a few try experimenting with a mixture of both. See plates 1 and 2 (back cover). After the first two or three sessions some children will exhaust their supply of certain pieces and require more, say the cones, and should be allowed to obtain these from other children using the material but not those particular pieces. We have found that to
gain complete satisfaction a child should be able to have the shapes of the correct colour and size that he needs.

## 2. Symmetry \& Balance

The discerning teacher who has carefully observed and recorded the variety and types of constructions accurately will have discovered that they fall basically into two groups; namely, those built upwards and those spread outwards. (See plates 3 \& 4). They will probably have noticed also that almost without exception the tall structures are built symmetrically. In the case of ' $G$ ' blocks, there is a symmetry of colour as well as size and shape. Often the tall structures terminate in a point, the child having used either a yellow cone or a yellow pyramid. It will be found that frequently two of these three pieces have been used in the general structure, and rather than discard the third the child includes it to complete his building.

We have come to the conclusion, after several years of observation, that the feeling of symmetry is intuitive, and satisfies an innate desire from within. For instance, in response to the question 'Why did you put that piece there?' the child will probably reply, 'Because it looks right.' or, 'Because it doesn't look right if I put it anywhere else.'

When working with infants it is suggested that the satisfaction gained by the child through the medium of construction and experimentation should not be jeopardised by the introduction of mathematical concepts beyond their understanding. Junior school stage is quite soon enough, and then only after considerable experience.

After having experienced sufficient periods of free construction and every child having had the opportunity of using both ' $G$ ' and ' $A$ ' blocks it would seem advisable to draw their attention to the phenomena of symmetry. The set of Poleidoblocs ' G ' is the perfect vehicle for experimenting with three dimensional symmetry. After only one period of discussion along these lines, and in response to the question, 'Can you find a line that will exactly divide your building in half?' many of the children will find two such lines. Since precise vocabulary should be of increasing importance, and Juniors enjoy learning correct mathematical terminology, then the word axis or axes (plural) of symmetry should be used in discussion. After such discussion children's structures become more ambitious. It will be found that some, having set out to construct buildings round two axes of symmetry, find that in some cases there are four (Plate 5).

After the simple forms of line symmetry have been explored rotational symmetry should come under discussion. Since structures made by the child cannot be physically rotated it becomes necessary for him to move round to discover how many identical views he can find of his building. (This could be introduced when the teacher, on seeing a suitable structure asks, 'Which is the front?'). An interesting example of rotational symmetry can be examined on Plate 6. The tower has been constructed in such a way as to form a square topped, rectangular block. (Notice the overlapped yellow slats and the method used). The four green horizontal slats project from the faces of the yellow ones avoiding the vertical yellow edges and the final cone-topped structures are in perfect balance at the end of each of the four horizontal green slats. Each of the four obvious 'fronts' is, therefore, asymmetrical when viewed separately. But, the structure viewed as a complete unit has two axes of symmetry,
and can be rotated four times. (This structure was built by two 10 -year-old girls of only average ability. After considerable discussion they were well satisfied with their structure, which they said was "Just right now.") A structure such as this would make a good starting point for a discussion of rotational symmetry and evoke a completely new series of purposeful constructions.

At this stage it becomes very necessary to provide ample material and easy access to more than one box of blocks. We found that when children needed more blocks they discarded, in the main, the suggestion that they supplement the ' $G$ ' blocks with ' $A$ 's' or vice-versa. Does this perhaps suggest that the idea of 'sets' is an innate quality?

Another idea to help consolidate the concept of symmetry is the 'matching game' (Plate 7) This is played in pairs, each pair to be provided with a complete box of blocks, either ' G ' or ' A '. The axis of symmetry must be decided first. If a double desk is used, as in Plate 8 , the axis is already apparent but where flat-topped surfaces are used an axis should be drawn, or a piece of Sellotape used to divide the table in half. The game starts with the first child placing any piece anywhere in her half. Turns are then taken in placing and matching until a mutually satisfying structure is obtained. Sometimes the children will agree to join their structures and at others prefer to create two separate but identical or 'mirror' buildings. They also tend to make up their own rules as they go along. For instance, when Sally and Carol were playing this game it became necessary, after placing the first slat on top of a blue cylinder, for Sally to put two pieces on to balance the structure. Carol was quite happy about this arrangement and allowed Sally to add two pieces each time. (See Plate 7)

It is of interest also to note that one or two bright children had covered up ink-well recesses, apparently because of the imbalance caused to the overall symmetry.

We are sure that ingenious teachers will think up many other ideas to help children to develop their natural interests in this extremely absorbing aspect of mathematics.

## 3. Sets

Teachers who are experienced in the teaching of sets will appreciate the value of Poleidoblocs in this branch of mathematics. When the children are familiar with the colour, shape and size of all the pieces there are many ways in which this work can be applied, and at the same time prove very stimulating and interesting for the young experimental mind.

For teachers who have little knowledge of Sets we suggest the following lines of development.

It is obviously necessary to understand the terminology of Sets, and for this reason we have included the most important concepts below. It should also be made clear that we have confined our outline of suggested work to Poleidoblocs ' $G$ ', since they lend themselves to natural and spontaneous response on the part of the child. Later on, many teachers will want to give more searching experience both in the concrete and the abstract; i.e. birds, toys, children, numbers etc.
a) Universal Set: This applies to one complete 'Set' of 54 pieces of Poleidoblocs ' G ' and will be referred to as ev.
b) Sub-Set $=\subset$. A sub-set is any set of pieces which is wholly contained in ev.
e.g. The 'set' of red pieces or, mathematically speaking: -
\{Red pieces\} - the set of cev-Sub-Set
c) The Empty Set $=\varnothing$ or $\}$. The Empty set is a set containing no members.
e.g. $\{$ purple pieces $\}=\varnothing$
d) Partition (Has no mathematical symbol)

Partition is an expression used when the whole Universal set is divided into Sub-sets which are 'disjoint'. No piece is a member of more than one sub-set.
e) Member $=\in$. This is simply the word used to state that a piece belongs to a defined Set. It is also an occasion referred to as an 'Element' in some text books, but we have found the word 'Member' more acceptable to children.

Example: the cone $\in\{$ \{yellow pieces $\}$ or a 2 " cube $\in\{$ cubes $\}$.
To say that a piece does not belong to a Set one uses the same symbol crossed through i.e. $\notin$.

Example: The pyramid $\notin\{$ blue pieces $\}$.
f) Intersection: $\cap$. It can readily be seen that a piece could belong to more than one Set; for instance, if we take the red pieces and cubes then we find that there are four red cubes which belong to both Sets.

Example: $\{$ red pieces $\} \cap$ ccubes $\}=\{$ red cubes $\}$.

## g) Venn Diagrams

To express intersection in a more comprehensible form, the Venn diagram is generally used. A series of circles is all that is required to express whatever one needs to describe.

Examples:

b) Union $=\mathrm{U}$. This this the term used for all members of the two Sets which may or may not intersect.

Example:


When introducing the study of Sets to children we have found that the majority of them, when asked to sort the blocks do so by setting in colour. When asked if there are other ways in which they could be sorted they are quick to suggest several such ways, the most popular being the following:
a) Those with curved edge, and those without.
b) Those with a rectangular cross section and those with a square cross section. (this leads to an interesting discussion with children as to what happens to the triangular prism, the pyramid, the pillar and the flat blue square).

It can readily be seen that this is an 'open-ended' discussion to which there is no right or wrong answer. As long as the child can justify the inclusion of any piece in any set, by its own definition, then the child is right. Experimenting with Poleidoblocs along these lines is very rewarding in that the children do discover conceptual ideas for themselves and this becomes forcibly apparent in their discussions. The natural development for those teachers who wish to go on a little further with Sets is to apply the knowledge gained by giving other
experience, as previously suggested, although most teachers will think up other ideas of their own.

## 4. Equivalence

Teachers have frequently discussed the problem of what is equal and what is equivalent. Children using Poleidoblocs will help clarify this situation to a large extent since their ingenuity in 'building-up' to acquire an equivalent volume is readily observed in their structures.

As a result, there is a ready-made opportunity of introducing discussion with the children to help them towards conceptual understanding. It is suggested that the early work be confined to the use of the ' $G$ ' blocks to limit the variety of pieces available. It will be seen that the later extension of this particular aspect of work with children will be very rewarding and interesting once they transfer to the more challenging ' $A$ ' blocks.

Teachers will obviously have to look for suitable structures to draw attention to but perhaps a start could be made along these lines. When seeing that a child required another red cube in his structure but uses but uses 4 red prisms or 4 red pillars to build up an 'equivalent' shape, a general discussion could follow as to how many ways this shape could be made. Teachers may find, at this stage, that some children are reluctant to use the blue pieces since they do not match in colour but further discussion placing emphasis on shape and size (volume) will readily overcome this doubt.

From this point the children could go on to discuss the equivalence value of one green slat two green slats - four green slats, and then, in a similar way, find the equivalence value of the yellow slats. It will soon be discovered that there are innumerable combinations using just these pieces alone. However, plenty of experience is very necessary if children are to be helped to grasp the idea of equivalence fully. At this stage, it is a good idea to allow further work along these lines to be pursued in pairs since the stimulation and interest derived is found to be mutually beneficial.

The extension to the use of the ' A ' blocks is now important since the much wider scope extended will help to consolidate the whole concept of equivalence. Colour is now excluded and full attention given to just shape and volume. The pattern to follow is similar to that used with the ' $G$ ' blocks but it will be found that a great deal of excited discussion will emerge as a result of the discoveries made by the children, especially when the triangular pieces are examined.

When sufficient time has been given to the discoveries of equivalence values of the ' $A$ ' blocks alone, it becomes even more interesting to allow both ' $A$ ' and ' $G$ ' blocks to be brought together. Now the equivalence values of the red prism, the red pillar and the green cube can be found.

The purposefulness of this kind of activity enables the child to develop his powers of observation, thought and experimentation and come to a greater understanding of the patterns in mathematics. The tremendous satisfaction found by children of poor manipulative ability is profound; and perhaps of equal importance is the fact that all children are able to discard an unwanted structure quickly and start all over again. Emphasis
should always be given to experimentation. It has been found on occasion that a very bright child when asked how many blue cubes were equivalent to a red cube confidently replied four; only to find that when asked to construct it eight were required. Other children were even more surprised to find that 27 small plain cubes were required to construct an equivalence of the green cube.

Time devoted to this kind of work with children must prove of real worth later because of its foundation forming qualities.
5. Volume


It is suggested that the early work in Volume should be based on the direct result of the children's study of equivalence.

As a start, the three blocks (see left) could be introduced and the question posed "Which of these three blocks is the biggest?" The bright child will most probably respond with something like this: "It all depends on what you mean by biggest". The less able child is inclined to opt for the red prism, no doubt because of its 'different' shape. Some children will say that the pillar is biggest because it is taller - but seldom, if ever, will a child opt for the flat blue square.

The next step is to extend the questioning to include "Which of the blocks takes up the most air space?" We consider this kind of question to be one of the simplest, and unambiguous, ways to explain volume to children, at this stage. Again, from the brighter children, will come the reply along these lines: "They must be all the same because each is a quarter of the large cube". The less able children will take a lot of convincing and will require additional handling, manipulating and building before they will accept this fact completely. As Volume is a measurement as well as a concept, it is suggested that a start be made using the simpler shapes in establishing the formulae for the calculation of volume. For this reason, the choice of the blue cube as the unit, and the equivalent values of the red cube readily lend themselves to the required measurements which can be tabulated, and the results recorded. Initially, children should check that every edge of the blue cube is in fact exactly one inch in length. They will then be quite happy to use its correct term, namely a cubic inch.

The next step is to establish the volume of the red cube. This can be done simply by constructing and applying previously acquired knowledge from the work on equivalence.

Using the blue cubes the children can now build a similar cube alongside the red cube. On counting the number of blue cubes it will be quickly discovered that there are eight in number. It now becomes a simple teaching point to lead the children to the understanding that the red cube measures eight cubic inches. Further application of the concept of
equivalence should establish now that all the equivalent values of the red cube will have a volume of eight cubic inches. With ample experience of the measuring and the tabulating, and arriving to an acceptance of the fact that all the answers are correct, the children come to realise that by multiplying the measurements of length, width and height together will result in the finding of volume in cubic inches.

This concept can be readily extended to include similar experience with the ' $A$ ' blocks, should the teacher consider it profitable or necessary. For instance a 2 " cube can be built using eight 2" based triangles giving a volume of eight cubic inches and when halved, a prism of four cubic inches. This sort of extension, however requires careful teacher guidance since there is a strong possibility of the child measuring diagonals instead of the sides of the right angle.


## 6. Area

It is assumed that a good supply of plastic 1" squares are available for use. To supplement these, we suggest that others are added, some halved diagonally and others longitudinally. These could, of course, be made from thick card.

This section on Area should be approached with an experimental open-mind! To try to find a sequence in the development of a scheme will only serve to inhibit the child's sense of discovery. Although many teachers will devise interesting approach avenues for themselves, we feel that one successful way of introduction is to start with the rectangular-face blocks, both ' $A$ ' and ' $G$ ' when the children are simply asked to find those which can be completely covered by the whole inch squares. From this activity they will devise their own tables of measurement, similar to that shown below.


You will also find that most of the children derive great pleasure in discovering that many of the blocks have rectangular faces and quickly come to realise the relationship between measurement and area. The next stage should then concern discussion with the group to ascertain how one could find the area without using the square inches. In all probability one of the children will say that on one of his blocks he has two rows of 6" squares, making twelve altogether. Someone in the group will obviously volunteer the information that all one has to do is to multiply length by width to get the answer (Working with many different groups of children the outcome follows closely to the pattern of answers given above, although the actual situation varied). Now comes the time when this concept should be put to the test, especially as some children will not as yet have grasped the idea.

This newly discovered theory can now be applied to those rectangular blocks that measure $1 / 2$ " in width. It is better to use the $5^{\prime \prime} \times 1 / 2{ }^{1}$ block first since it does not calculate to an exact number of whole square inches. In the first instance the block should be measured by the children to find out if it does in fact, measure 5 " in length. Making use of the half square inch pieces it can quickly be discovered that five of these are needed to cover the complete face. This method can not be applied to the other similar blocks to help consolidate the idea.

A natural progression from this is to find the area of the triangular pieces, but it is suggested that only the flat triangles from the set of ' $A$ ' blocks should be used since the triangular faces of the pyramid are not right-angled triangles, and the red prisms contain a triangle which has the same measurements as one of the flat triangles from the set of ' $A$ ' blocks. As this is one of a series of four, it seems logical to restrict measurement to these.

However, since only two combinations of triangles give results that can be easily checked by using square and $1 / 2$ " square inch pieces it is suggested that only those teachers who wish to extend the study of triangles beyond the Poleidoblocs should embark on this more advanced geometry. For those teachers who wish to pursue this aspect further, a suggested method is shown below.

$2 \Delta$ 's can be covered by 1 sq. inch. Area of each $\Delta=\frac{1}{2}$ sq. inch. Measurement of $\Delta=1^{\prime \prime} \times 1^{\prime \prime}$

By using a different arrangement of the 2 " triangles it is possible to show that the three figures below have a similar area of 4 square inches, hence to evolve methods of discovering the areas of triangles and parallelograms. We have included this particular section because of its undoubted fascination for the older child who would enjoy investigating the properties of geometric solids.

We have found no better material than Poleidoblocs ' $G$ ' to achieve this purpose.

```
Base of parallelogram \(=2^{\prime \prime}\)
Perpendicular height of parallelogram \(=2^{\prime \prime}\)
Area of parallelogram \(=4 \mathrm{sq}\). inches
\(\therefore\) To find the area of a
parallelogram \(=\) base \(\times \perp r\) height.
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## Introduction to the Record Form <br> The use of Poleidoblocs in Free Construction sessions at schools

## Introduction to the class

The full box should first be demonstrated to the whole class, the teacher removing the lid and showing the children how nicely the blocks fit into the box, making a nice pattern. That is how they always have to go back after use.

The teacher should then in her/his own words explain that these blocks are something quite different from ordinary building bricks; they come in different colours and different shapes (take one block of each kind out of the box and place them on the Table in front of the box) - explain that the blocks fit together in certain ways which the children themselves are going to find out, and that many different things can be made with them. They are nice to touch and must be handled carefully; they are made especially for schools, so they are not playthings; each of the children will get their turn to use them.

The teacher then puts the blocks back into the box, each in its proper place, so the children get the feeling of careful handling.

## Administration

Free construction with Poleidoblocs should be part of ordinary classroom routine.

One or two children should be selected to work with blocks at any time during school hours when the rest of the class needs less attention.

Each child should work with a complete set and should be seated so that he cannot see what the other child is doing (when two children are working at the same time).

The contents of one box of Poleidoblocs $G$ should be placed in a casual heap on the table in front of the child - and THE BOX REMOVED - the teacher should then say, 'Now make with these whatever you like and tell me when you have finished' leaving the child to get on by himself.

Time limit should be around 20 minutes; most children use less. But if a child is long in getting started or in the process of finishing his construction, he should be allowed longer time. If nothing is completed within half an hour, the session should be ended.

While the child (children) is at work the teacher should devote as much time as can be spared to observe the child in order to be able to fill in the Record Form.

When a child has finished it is the teacher's task to find out what the child has made, without asking leading questions. It is usually enough to say something like "this looks very interesting, would you like to tell me about it?". Take time enough to talk to the child about his work so he feels it to be important.

Some children may feel that a certain response may be expected of them, being 'school work' (a 'right' or a 'wrong' response); it is the teacher's task to reassure any children who feel like that; to tell them it is a 'making-things-time' and a 'finding-out-time'.

The blocks should then be put in the box in the correct order; most children like doing this.
The Record Form is divided into ten main sections with space for recording six constructions from each child (each child having his own Record Form). Only sections (1), (7) and (10) need any writing, the rest only a tick in the relevant column; the back of the sheet can be used also for further explanations.

Re Type of Constructions: the overall shape is decisive; is it taller than wide or vice versa; is it spread out on the table as a town, village, street etc.; does it have the form of an enclosure (many girls make enclosures and call them 'houses') or does the child experiment with finding out how many blocks make this, for instance?

Re Representational: objects mean anything such as cars, planes, furniture, machinery, swings and so on: external scene(s) cover houses, castles, stables, towns, villages, streets, shops, airfields, schools, playgrounds, bridges etc.; interior scene(s) refer to anything inside a house, shop, place etc.

The child's own description is often very vivid and should be recorded as exactly as possible on the back of the sheet.

In Infant Classes it is advisable to use only the G box, as the amount of pieces in the A box is confusing; also colours appeal very much to small children. Each child should preferably have six sessions with Free Constructions during 2-3 terms before the knowledge gained of the relationship of the pieces is used in actual teaching.

In Junior Classes Poleidoblocs G should always be used first for at least one term. Poleidoblocs A can then be introduced and used till some familiarity with them has been gained. The use of $G$ and $A$ can then alternate according to what the teacher may want the class (or the individual child) to work on.

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## See Next Page for Back Cover Plates




[^0]:    (or any other combination of these)

