The Kindergarten Origametria Programme

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Introduction

The Kindergarten Origametria (KO) program (KOP) is a program to train kindergarten teachers to work with the geometry curriculum of the Israeli Ministry of Education, using origami as a learning tool. The program uses the imagination of kindergarten-age children aged 4-6 years as the focus of the activity, involving them in a series of creative folding activities that acknowledge their limited motor skills. The KOP is a tool for the kindergarten teacher to make an activity in a creative environment, building a strong mathematical base for the children.

The emphasis on imaginative play and experiment as a means to learn, though common in many kindergarten activities, is historically uncommon as an approach to using origami as a learning tool, where teaching named models is the norm. In this way, the KOP may be considered an unorthodox approach to origami.

The paper describes the progress of the KOP since the brief account eight years ago of the pilot KOP given in *'Origami^4'*, pp. 464-465 [Golan 09].

ONE
The Structure of the KOP Courses for Kindergarten Teachers

The first KO pilot course began in 2005. In 2010, the program was re-written with supervisors from the Ministry of Education and with input from specialist teachers and professors of math and math education. To date (summer 2014), the KOP has been studied by teachers in 120 state kindergartens, mainly in Tel Aviv. The program is ongoing and will continue to expand in the foreseeable future, supervised and funded jointly by the Ministry of Education and by local Departments of Education in different cities.

Each course runs for a total of thirty hours, over 8 sessions, spread over a period of several months. Each course accepts twenty kindergarten teachers (KTs). Each KT is required as part of her Terms of Service to undertake a minimum number of courses each year and attending the KO course contributes to meeting this requirement. Some KTs choose to take the course, while others are recommended to participate by their Supervisors.

The KO course divides into three parts:

1. Learning Topics of Geometry According to the Kindergarten Curriculum (10-hours) The KTs are taught basic geometric knowledge, which many did not know, had forgotten, or had mis-remembered. They are taught the terminology and definitions they will need when teaching the KOP and later, they are taught additional terminology and definitions in advance of what they will need in order to feel they are teaching within their knowledge.

This knowledge is learnt by folding, led by the teacher. The learning is thus folding-based and not lecture-based. During the process of folding, the geometry of the paper is described and analyzed by the KTs.

2. The Method of Using the KOP Activity in Kindergartens (12-hours)
The KTs are introduced to the method of how to conduct KOP activities (three sample activities are described below in Part Four). Between each course session, every KT introduces what she has recently learnt as an activity in her kindergarten and reports back to the class on her experiences. They are encouraged to take photographs and to make short movies, to assist with the description of their experiences. Feedback is given by the teacher and other KTs.

3. Additional Geometric Information (10-hours)
The KTs are taught basic three-dimensional geometry (cubes, cuboids and pyramids) and the relationships between members of the triangle and quadrilateral families (for the quadrilateral family, for example, the similarities and differences between a square, rectangle, rhombus, parallelogram, trapezium and more).

The KTs are also introduced to the theories of Piaget [Piaget et al 99], van Hiele [van Hiele 99] [Crowley 87] and Vygotsky [van der Veer 91], regarding how children learn and how this is applied to the KOP.

After the course has concluded, visits are made by the course teacher to each KT's kindergarten to observe a KO activity, to help the teacher fine-tune her implementation of the program. It is important that with these visits, the program is tailored to fit the individual circumstances of each kindergarten, not vice versa.

The KOP method is based on encouragement, curiosity and learning through experimentation, allowing the children to play with their paper as an imaginative and fun activity. The geometric research undertaken by the children during the KOP activity develops strong mathematical thinking skills.

In the past year, the program has received input from Dr John Oberman, PhD, M.Sc, DipEd, Director of Pre-service Mathematics Training, Shaanan Academic College, Haifa, Israel, who has helped relate the open-ended folding experiments undertaken by the children during the KOP activities to the kindergarten geometry curriculum.

TWO
Distinctive Contributions of the KOP to Geometric Education in the Kindergarten

The KOP repositions origami as an activity which uses the imagination of young children aged 4-6 as the basis of the teaching method. This focusing of an activity around a child's imagination and on discovery through experimentation is not new in kindergarten education – indeed it is the basis of well-established methodologies such as the Montessori and Steiner systems – but is an unorthodox use of origami, where teaching named models is the norm.

The KOP, along with many other making activities such as working with Plasticine and wooden bricks helps with developing a child's imagination, fine motor control, spatial awareness, group work and communication skills. However, there are two aspects to the KOP which may be considered distinctive contributions to geometry education in the

kindergarten.

1. The KOP helps young learners differentiate between different polygons by asking them during the process of folding to count the number of corners and sides, to name different polygons, to intuitively recognize right angles in squares and rectangles and to create and identify simple mirror symmetry. These concepts are developed by asking the children questions such as: what is the same and what is different with the shapes they have made or, which shapes would they like to put together. After discussions between the KT and the children, the formal language of geometry will develop as a need for communication. The children are not given knowledge or asked to learn definitions 'by rote', they are given methods to observe and explore, from which definitions can be deduced. This method, once learnt and practiced, can be used at any time.

Many KTs report that after running the activity, the children from the group will teach other children in the kindergarten what they had learnt, using correct geometric terminology.

2. During the process of folding, the paper will change its shape many times; from a square to a rectangle, then perhaps to a triangle or hexagon and back to a square. This continual process of creation, change and re-creation allows the child to identify a polygon in different circumstances, at different rotations and at different sizes. Further, at times the teacher will hold her paper deliberately askew and ask – for example – if her square is still a square. In this way, the children learn to recognize polygons in diverse and unfamiliar situations and thus gain a stronger understanding of their individual characteristics.

THREE
The Four Ways to Develop Creative Thinking

These four ways guide the structure of the KOP courses for kindergarten teachers and the approach of the teachers to their KO activities. They are based on the research of Guilford, Christensen and Torrance [Guilford 67] [Guilford 73] [Torrance 80].

1. Fluency

The ability of the child to make a few samples, cases or situations within the limits of the task.

2.Flexibility

The ability of the child to move from one way of thinking to another and to produce samples and solutions that relate to a different category.

3.Elaboration

The ability of the child to expand the knowledge, to add detail and to develop it in combination with other ideas.

4.Originality

The ability of the child to relate to certain problems in a new way, in a different way, so he can produce unexpected situations.

FOUR
Three Examples of KOP Activities

During their KO course, the KTs are taught twelve KOP activities that relate to different topics within the geometry curriculum. Here are three sample activities, described step-by-step. The full twelve topics can be found in Appendix I.

Activity A: Researching Squares and Rectangles

1. The KT gives a sheet of square origami paper to each child
2. The children count how many sides and vertices they can find and check the lengths and angles with a straight edge (usually a square of paper folded in half long edge to long edge, three times)
3. The KT asks the group to assemble the squares to make one big square (composition and decomposition). See Fig 1.
   (KT questions: do all the squares always make a big square? What are the characteristic of the big square? These questions provoke much discussion and research about what is a square).

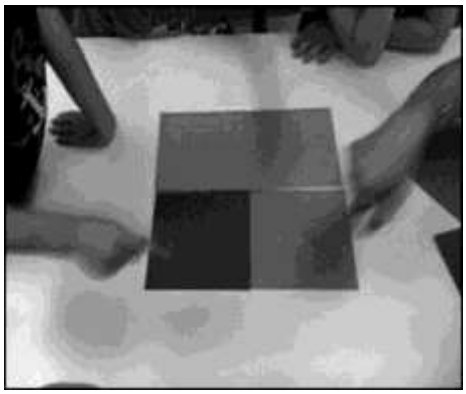

Fig 1. The children discovering the characteristics of a large square

4. The KT shows the children how to fold the square in half to make a rectangle
5. She asks the children to count the number of sides and vertices and to measure the lengths of the edges.
6. The children are asked to assemble the rectangles without overlapping to create an imaginative shape. See Fig 2.

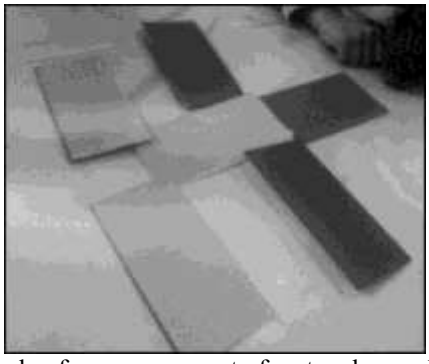

Fig 2. An example of an arrangement of rectangles made by the group.

7. The KT asks each child what s/he can see in the arrangement, asking for a detailed description (so, for example, if the answer is 'a robot', the child is asked to show the arms, head, legs, etc). Usually each child sees a different subject (robot, butterfly, spider, etc).
8. The KT asks the children what is the difference between a square and a rectangle and how many of these rectangles will make a square (note: it is recommended that before this KO activity, the KTs run activities to learn 'long' and 'short').
9. The KT asks the children to fold a long side to the opposite side. The children again check the polygon.
10. The KT asks the children to fold one short side to the opposite and parallel short side and to check the polygons.
11. The KT inserts her finger into the short side of the rectangle and asks each child what it is. The children draw on their own paper. See Fig 3.

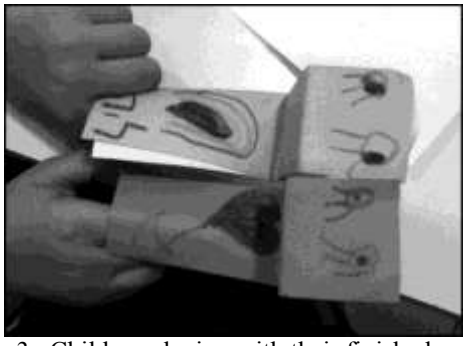

Fig 3. Children playing with their finished work

Activity B: Defining and Finding Polygons

1. The KT begins the activity by repeating Steps 1-8 of Activity A.
2. The KT asks the children to fold back the open corners as shown. The position of the folds is not important. See Fig 4.

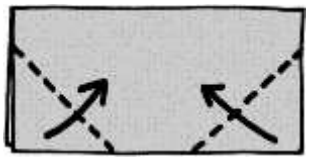

Fig 4.

3. Turn over.
4. The children count the number of edges and vertices and discover it is a hexagon.
5. The children fold in the corners of the long edge, as shown. Again, the position of the folds is unimportant. See Fig 5.

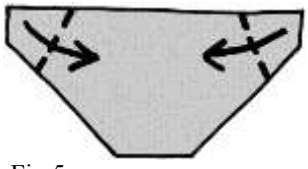

Fig 5.

6 Turn over.
7. The children fold back the corners to reveal white paper. See Fig 6.

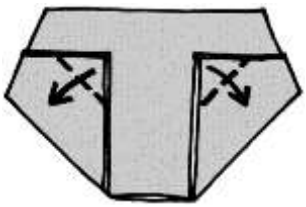

Fig 6.

8. The KT inserts her finger into the pocket and asks each child what it is. The children draw on their own paper. See Fig 7.

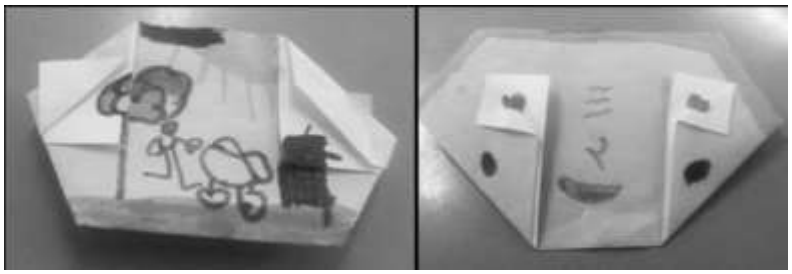

Fig 7. An example of how differently two children saw their finished work

Activity C: Defining and Researching Triangles

1. The KT gives a sheet of square origami paper to each child
2. Each child folds the square in half, corner to corner, to make a triangle.
3. The children are asked to assemble the triangles without overlapping, to create an imaginative shape.
4. The KT asks each child what s/he can see in the arrangement, asking for a detailed description. See Fig 8.

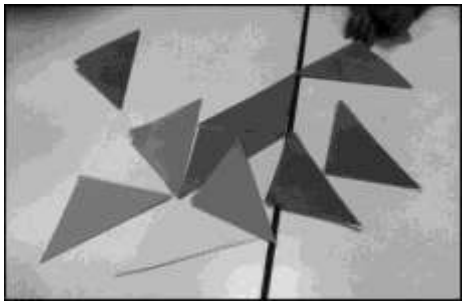

Fig 8. An example of an arrangement of triangles made by the group.

5. Each child takes back their triangle and checks with the KT how many sides and vertices it has.
6. The KT asks the children to try to make a big triangle from four individual triangles (composition and decomposition)
   (KT questions: do the 4 triangles always make a big triangle? What are the characteristics of the big triangle? These questions provoke much discussion and research about what is a triangle)
7. Each child takes back his/her triangle. The KT asks the children to fold vertex to vertex to make a smaller triangle, then to open the fold.
8. The KT asks the children how many triangles they can see. (The answer is three: one

large and two small triangles)

9. The KT asks the children to fold the apex to the base, to create a trapezium.
10. Turn over.
11. The KT asks the children to count the sides and corners to check if the polygon is still a triangle.
12. Turn over again. The KT asks the children to fold the bottom corners to the middle of the base.
13. The KT asks them to name what they have made and to draw on it.

Fig 9. Collage of six examples of the same folded shape, perceived as different subjects by the children.

FIVE
The KOP and Friedrich Froebel

The KOP is often compared to the well-documented use of origami (*'papierfalten'*) by the German educator, Friedrich Froebel (1782-1852). While there are similarities between the two, there are also many differences. The table below makes a comparison between the programs.

Froebel	KOP
Origami was taught as the 18th of 20 Gifts, when the children were 7 years old.	The KOP is taught to children aged 4-6.
Froebel's 20 Gifts were all geometric in concept. So, by the 18th Gift, the children were well-used to working with geometrical shapes and forms.	For many children, the KOP is their first experience of working with geometric shapes and forms.
An emphasis in the 'Folds of Life' on	An emphasis on imaginative play, with

making recognizable models of objects familiar to the children (furniture, utensils, boxes, etc).	the children naming what they have made.
An emphasis on the achieving of a final model.	An emphasis on geometrical analysis and group discussion during the folding.

Table 1. A comparison between Froebelian paper folding and the KO program.

Conclusion

Although unorthodox in its use of origami, the KOP has quickly established itself as a program for the teaching of the Israeli Ministry of Education's geometry curriculum for kindergartens, proving itself popular with Ministry officials, the teachers and also with the children. Formal assessments of the KO courses for KTs written by participating teachers consistently rate the courses very highly for didactic relevance and for consistent success within the demanding real-world circumstances of different kindergartens with different population groups.

The key elements of the program are the emphasis on imaginative play with folded paper and group analysis of a geometric topic or open-ended problem. At no point in the activity can a child consider himself to have failed, thus encouraging participation and a willingness to experiment without limits. This approach, although puzzling to many people familiar with origami and the teaching of origami to older children and to adults, relates to the educational level of kindergarten age children and their predisposition to learn through imaginative play [Clements et al 09] [Cramond et al 05] [Ginsburg 06] [Pandisco 98] [Torrence 67].

Further, the structure of the 30-hour courses undertaken by KTs to learn the KOP and the follow-up visits to each teacher's kindergarten to see the program in action, ensure that the philosophy of the program is translated into a successful activity.

Since the relationship between the Ministry of Education (MoE) and the KOP is new and its place within the national curriculum has yet to be fully determined, there is as yet no formal quantitative assessment regarding the comparative effectiveness of the program. However, it is a requirement of the MoE that KTs study and document the progress of each child in each area of the curriculum, including mathematics. From this documentation, it is evident that the KOP makes an effective contribution to the learning of the geometry curriculum and is a popular activity. It is this positive assessment of the KOP that has led directly to the rapid growth in the support given to it by the MoE. Many future KOP courses are planned.

Finally, the KOP is best assessed by the teachers who have been trained to use it. Here is a testimonial from one KT who took the KOP course:

> *At the beginning I thought Origametria was just folding paper models, but then I saw it was really about geometry and I was afraid to introduce it as an activity in my kindergarten because I don't know much about geometry. Although we learnt the basics of geometry on the course, I was still afraid and began the activity with a lot of fear, but I saw the children enjoyed it. They loved it! They were excited and waited for their activity.*

I didn't have enough time to work with all the children, so I worked only with the oldest group. Afterwards, they introduced the activity to the younger children without my involvement and using correct geometric language. It was very beautiful to see!

I feel I'm only at the beginning and I need more time to work with it, but I feel the program is important and makes a valuable contribution to geometry in the kindergarten.

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Appendix I

These are the twelve topics studied on the KOP course for KTs.

Shape
1. Identify and research each polygon according to the number of sides and vertices.
2. Identify and research between long and short sides.
3. Identify and research quadrilaterals according to the number of sides and vertices.
4. Creating a paper ruler and learning to measure long and short sides, vertices and to identify right angles.
5. Identify and research squares according to the number of sides, vertices and right angles.
6. Identify and research squares and rectangles according to the number of sides, vertices and right angles.
7. Identify and research different quadrilaterals such as a square, rhombus and rectangle according to the lengths of the sides and the number of vertices.

Mirror Symmetry
1. Identify and research mirror symmetry in triangles.
2. Identify and research mirror symmetry in quadrilaterals.

Solids
1. Identify and research cubes by building cubes and learning about the structure.
2. Identify and research three-sided pyramids.

Composition and Decomposition
1. Building different polygons from a large number of triangles and researching topics studied previously.