Origametria: A Program to Teach Geometry and to Develop Learning Skills Using the Art of Origami

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1 Background

The name *Origametria*^{TM} is made from the words *origami* and *geometry*. The term was created by the Israeli Origami Center (IOC) to describe its innovative program to teach curriculum geometry through origami.

In Israel, the *Origametria* program is taught in 70 Jewish, Arab and Christian schools. The IOC has a team of 40 teachers who are trained to teach the program. Thus, each week, about 10,000 school students around the country, study *Origametria* as part of their curriculum. In 2008, after several years of scrutiny, the Israeli Ministry of Education formally approved the program. Soon, a pilot course of *Origametria* will open in a college of teacher training. If successful, courses will be made more widely available. At present, the program is taught to elementary school students (grades one through six), but there are plans to expand it into high schools.

1.1 Origins of the Program

In 1992, the IOC began to teach an origami program with the purpose of developing learning skills. The program was designed to enhance self-esteem and a sense of accomplishment, while developing learning skills such as motor skills, spatial perception, logical and sequential thinking, hand-eye coordination, focusing and concentration, aesthetics, 3D perception, and principles of basic geometry.

1.2 Why the Program Changed to *Origametria*

Although the *Origami as a Learning Tool* program was successful, increasing year by year the number of schools in which it was taught, it became apparent that the natural long-term home for origami was not as a special learning tool class, but rather, as a class integrated into a particular subject of the school curriculum. Specifically, it was felt that origami should be integrated into the geometry curriculum.

After a year-long pilot, we found that *Origametria* was indeed an important tool and a powerful way to improve students' knowledge of geometry. The transition was not easy at first. When the system was introduced into schools that already had participated in our old program, we encountered some problems with the program's teachers: since those teachers came from a predominantly arts background and not a mathematics background, they had difficulty teaching geometry. Additionally, teachers who were familiar with the old program did not easily adapt to concepts of the new program.

Therefore, in 2002, we replaced almost all of our teachers. Each teacher we trained had to come with a background in mathematics. This, among other factors, greatly added to the success of our program. While the basic concepts, ideas, and didactic methods of the previous program remained in the new program, the class structure, goals, and subjects had changed. Without these adaptations, the program could not have succeeded.

The main decision to change the principal IOC program from origami as a learning tool to *Origametria*, was made after meeting the director of Ha'Achim School in Kiryat Malaachi. During the discussion, a mathematics teacher described how she taught two third grade classes and had noticed a significant difference in the spatial perception and understanding of geometry between the students of the two classes. Evidently, the IOC course was taught in only one of the classes – the class in which the level of understanding was higher. This realization gave the IOC the confidence to begin expanding the *Origametria* program.

2 *Origametria* in the Classroom

2.1 Lesson Structure

Before a lesson can begin, a specific topic of geometry must be chosen for teaching. This is often done in consultation with the mathematics teachers at

the school. The choice of topic depends on the requirements of the national curriculum for each grade.

Once a topic is chosen, an origami model is found which, in its sequence, focuses on that topic: for example, a model that may consist of many different triangles, or specifically isosceles triangles, or polygons, or bisections, etc.

During the folding of the model by the class, the teacher will stop after each new step to check if new examples of the chosen topic could be identified, and if they are the same or different from earlier examples. The process of identification can be summarized thus:

- *Geometric insight* – understanding of the topic using folds.
- *Exploration* – continuous search throughout the folding process.
- *Properties and context* – studying the topic in various ways using the folded paper or while folding. Importantly, each year we repeat topics taught in the previous year, in cooperation with the school's mathematics staff and the standard geometry curriculum.
- *Lesson summary* – At the end of the lesson we check if each student has acquired the geometric knowledge taught in that particular class. We specifically verify that the weaker students have understood the concepts. Significantly, after every lesson the students leave with a folded model, which serves as a motivational tool for future learning.

2.2 The Method of Teaching

Here are some of the principles that define the *Origametria* program:

1. *The way it is taught* – we do not use negative terms during our classes. For example, we will not use a phrase such as: "this isn't correct." Rather, we will say: "this is beautiful; now, open this and fold...". We do not criticize a student's folding. This ensures that even weaker students can fold like all other students. Indeed, everyone receives positive feedback.
2. *We never check the accuracy of folding* – we stress that accuracy is important, although "accuracy" is a relative term that changes from student to student. When a student asks the teacher if a fold is accurate, the teacher returns the question to the student, asking if they

think it is the most accurate they can fold. This obliges the student to inspect their work and to fold as accurately as they possibly can. Such an approach both improves the student's accuracy and prevents disappointment.

3. *Our teachers never touch a student's model* – a teacher will show a step using their own paper again and again. This gives a student a stronger sense of ownership and accomplishment, as their work is entirely their own, folded by themselves without any assistance.

4. *The choice of models* – we carefully select the models and improve their folding sequences, so that the teachers can explain the folding procedure once and the students should be able to follow easily.

5. *Positive reinforcement* – after each step, the teacher inspects a student's folds and gives them positive encouragement in Japanese, such as *"Ichiban sugoi!"* ("This is excellent!").

6. *The model is never named while being folded* – throughout the folding, the identity of the final model is never revealed. This has the double effect of focusing students' attention on the geometry of the current step instead of seeing it as a 'leg' (or whatever) and also of opening students' imaginations. It also gives control of the subject of the model to the teacher and concludes the lesson with a surprise.

3 The Advantages of Teaching *Origametria*

In *Origametria*, the specific model being taught is of little importance. More important is *the way* the model is taught.

Most of the success stems from a process the student undergoes while folding. For the student, the main goal is to create a finished model of an animal, a toy, or any other form. For the teacher, this is a secondary goal. The main aim of the program (and of the teacher) is to improve a student's knowledge of the geometric topic selected for the class, and to develop learning skills by exploring and studying the topic *while folding the model*.

The strength of using origami for this is that the geometry is inherent in the folding process – one needs only a quick look at any folding sequence to

identify geometric topics in abundance. For example, in the lesson in which we teach diagonals, we will look for diagonals while folding, check whether various folding lines are diagonals and explore the properties of the diagonal until we finally complete the model.

The students find the lessons fascinating. For many, it is their favorite lesson of the week. They are excited to fold a model, and enjoy exploring the topic with the teacher. For them, it is a game that uses several senses and provides a positive experience. This deepens their knowledge and motivates them to learn more. This way, the students will remember a topic, even after several years.

3.1 Reasons for the Success of the Program

There seem to be a number of reasons why the *Origametria* program is successful, and why it continues to expand:

- The rigorous didactic principles we employ in our classes.
- The focus on a single geometric subject per each lesson
- Our special methods of teaching origami ensure a student's success and satisfaction with the folding.
- There is close coordination between the IOC's *Origametria* teacher and the school's mathematics teacher(s), so that new topics are taught in parallel. A student who has just learned the concepts of angles in *Origametria*, for example, will have the chance to use his or her newfound knowledge in the regular geometry lesson. If this is a weaker student, their self-esteem will improve and they will be perceived by others as having a greater self-confidence.
- The IOC teachers are trained continuously. Once a month they attend a special training session with senior IOC Supervisors. I also visit the various school classes to observe in detail the teaching of each teacher, and to suggest how to improve their skills. The IOC's teachers and I introduce innovations and interesting, new ideas from our own experiences.

The success of *Origametria* can be described and measured at three levels:

1. *Cognitive:*
    - developing spatial perception
    - developing logical thinking
    - developing visual perception
    - improving use of imagination
    - building knowledge
2. *Emotional:*
    - building self-esteem
    - enhancing feelings of success
3. *Motoric:*
    - developing motor ability
    - improving hand-eye coordination.

4 Kindergarten *Origametria*

4.1 The *Origametria* Pilot in Broshim Special School

The Broshim Special Education School in Tel Aviv admits students from first to twelfth grades for a period of three or four years with the explicit purpose of enabling their rehabilitation into the school system. It has a special origami room to which the students come for origami lessons in small groups, or one-to-one with the teacher.

I have been teaching origami in the school for 15 years. While piloting the *Origametria* program, I taught it to first graders and also to the older students. It was apparent that the younger students found it easier to understand geometric concepts and terms after just a single lesson, whereas the older students required extra lessons. Regardless, all the classes in which I had taught *Origametria* had distinctly better retention of the topics. Even pupils who at first showed resistance to the program enjoyed visualizing the concepts being taught while folding a model.

The program in Broshim is dynamic. With each lesson we find more insights and discover other ways to enhance it.

4.2 *Origametria* in Kindergartens

The IOC has been teaching in kindergartens for 14 years, but we have always advised that children under the age of five should not be taught origami since their motor skills are not mature enough.

However, following my experiences with first grade students at Broshim School, I have developed a series of origami models that do not require accurate folding. This ensures that any child folding a model succeeds to do so, even if they are made inaccurately.

These models have opened a new approach to teach basic geometric concepts to pre-schoolers, and to improve important abilities such as motor skills, hand-eye coordination, and spatial awareness. The didactic principles are similar to those of *Origametria*, whereby we emphasize improving the self-esteem of a child by ensuring that they succeed in the folding, and by providing positive reinforcement.

It is my belief that the window of opportunity to acquire basic knowledge is between the ages of three to nine, because it is during these years that a child's imagination is at its most active stage. It helps the child to quickly and surely grasp the concepts of geometry. Consequently, *Origametria* is a powerful tool to provide the children with an understanding of these concepts. As students mature, they find it more difficult to use imagination to understand three-dimensional and abstract concepts. Therefore, I believe that the earlier we can teach *Origametria* to children, the better we can utilize the resource of imagination to teach geometry.

5 The Future of *Origametria*

Many schools provide very positive informal feedback on the successes of *Origametria*. However, we understand the necessity of a scientific analysis of this success, and we are planning to conduct a special study in which the effects of *Origametria* as a tool to learn geometry will be systematically measured.

We believe passionately in the validity of *Origametria* as a method to teach geometry, one that additionally (and importantly) uses origami as a tool to develop learning skills. *Origametria* makes the traditionally dry, abstract and remote subject of geometry not only fun to learn but also empowering. Furthermore, its hands-on approach to learning makes it an effective

tool for students with learning problems. While it makes geometry easier to teach, its effective use requires skills in the teaching of origami and of the specific *Origametria* method.

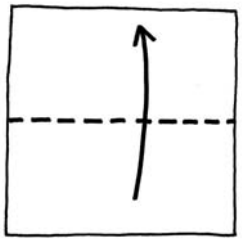
The program continues to expand within Israel and it seems likely to be adopted by schools overseas. In time, we would like to see it adopted as one of the accepted ways to introduce basic geometric topics as an alternative and/or an addition to the traditional ruler-and-straight-edge or chalkboard methods.

To conclude: a story. A school in Hod HaSharon introduced the *Origametria* program, but due to a funding crisis, had to cancel it in mid-semester. Such was their enthusiasm for the program that the affected students staged a placard demonstration outside the school, demanding the reinstatement of their *Origametria* class. Astonished by the students' enthusiasm for their geometry class, the school re-instated the program. They won.

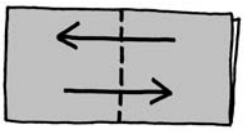
6 *Origametria*: an example

Here is an example of a model, taught according to the principles of *Origametria*.

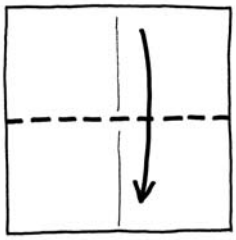
Polygon Heart by Paul Jackson



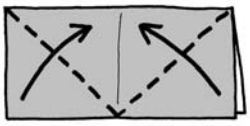
1. Fold to make a rectangle



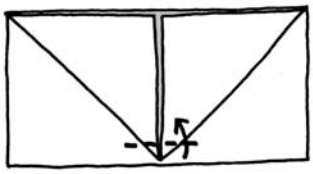
2. Fold as shown, then completely unfold



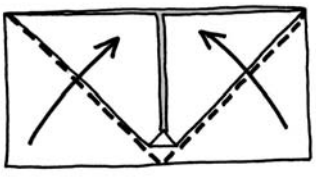
3. Fold a rectangle



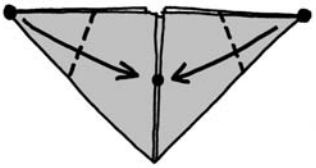
4. Fold in only one corner on each side



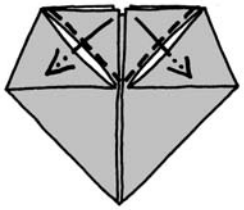
5. Fold up the tip



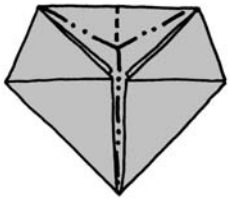
6. Fold the remaining corners over the top to look like the next step



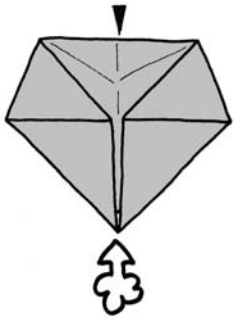
7. Fold the corners to the centre line to look like the next step



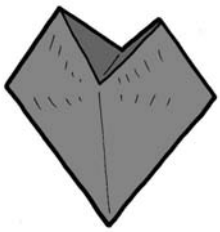
8. Fold the small triangles into the pockets



9. Fold as shown



10. Inflate. Push down on the top edge



11. Open the Heart as shown, making it hollow in the middle

7 *Origametria* Commentary

7.1 Main Topic: polygons

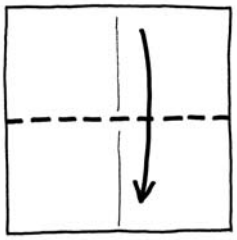
Topic of Lesson: 1st & 2nd grades – identify polygons by counting the number of edges. 3rd - 6th Grades – identify and describe polygons found during the folding.

Purpose of Lesson: to develop abstract thinking and to identify and describe all major polygons

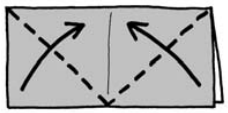
Definition of a Polygon: a closed figure made from 3 or more straight line segments

Definition of a Square: a 4-sided polygon having four equal sides and four angles of 90 degrees

7.2 Sample Questions:



Step 3: How many squares are in the paper?



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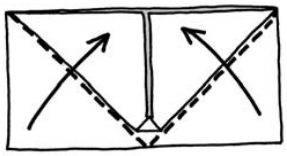

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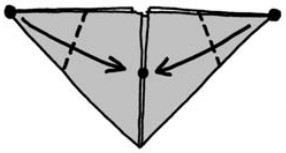

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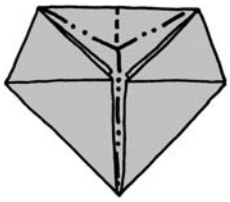
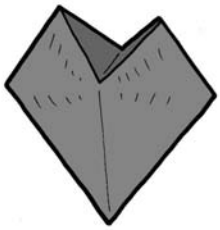
Steps 4, 6, and 7: How many triangles are found in the paper? Are triangles also polygons?



Step 9: What is the largest polygon?



Step 11: After the Heart is inflated, what polygon is made?

8 Acknowledgements

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An 8-minute movie about *Origametria* can be downloaded from the Green Fuse Films site: *www.greenfusefilms.com/origametria.html*