

# Math and Art

Argyri Panagiota, Mathematician in secondary education

[argiry@gmail.com](mailto:argiry@gmail.com)

## ABSTRACT

How can we induce motivation for learning mathematics? How can we eliminate students' negative attitudes towards this? As mathematicians, we are supposed to find new ideas and experiences aimed at the development of an all-round personality of young people, not taking on mind models. Within the context of teaching, Mathematics Incorporates innovative strategies such as active learning and students are encouraged to take their own responsibility for their learning, develop their own meanings and construct their own knowledge. The integration of interdisciplinary and experiential approaches are two key pedagogical principles that teachers need to take into account while scheduling their way of teaching. Moreover, modern learning theories attach great importance to the social-cultural factor and play an important role concerning the organization of courses that favor social interaction and collaborative, group learning.

This paper presents the methodology and results of the implementation of the Project in Lykeio Evangelikis Model School of Smyrna in Greece during the school year 2012-13 on *"The interaction of mathematics and art from ancient Greece to the 21st century"*

Finally we present the results and quotes from students' interviews, which reflect the positive feelings of satisfaction of their expectations and the development of positive attitudes and judgments towards the value and role of the Mathematical Sciences.

## INTRODUCTION

### Project in the Greek educational system

The novelty of projects implemented in the syllabus of high school as a distinct section of the curriculum, is based on the systematic involvement of the educational principles of exploratory learning, interdisciplinary knowledge domains binding to group cooperation and organization of students. (see "Innovation of Research Operations at the High School" , which is available in the website of the digital school, <http://digitalschool.minedu.gov.gr>). Students as young "intellectuals", "scientists" and "researchers" cooperate closely in the context of initiatives and options through their experience, they approach the new school knowledge in different ways through questions, experiments and investigations which refer in science. This is an important educational innovation, based on modern and applied pedagogical principles and aims to enhance the educational role of school to connect knowledge with reality (Matsagouras H. 2009: p.28).

Research studies show that the combination of interscience and teamwork of the projects raise pupils' interest and improves their attitudes, their self-esteem as well as their skills for cooperation and, by extension, learning and knowledge retention ( Rogoff et al. 1998, Prince, 2004: Joyce, Weil and Calhoun, 2008). *"Projects activate thinking, creativity and initiative of students .... They also increase the interest in individual courses, because students realize in practice the contribution of taught courses in understanding key issues of everyday life"* (Matsagouras H., 2009: p.19).

Also, according to research results (Matsagouras H., 2004 : p.22) cooperation between teachers of different specialties transforms school into a community of learning and professional development, which acts as a form of continuous education in schools, with significant benefits for teachers themselves , the school unit and especially students (see, Morrissey 2000, Achinstein 2002, Annenberg Institute for School Reform 2004).

The teacher-centered teaching of mathematical concepts in combination with the fragmentation of the syllabus of maths into chapters usually gives students the impression that maths is not related to the real world, resulting in negative attitudes and perceptions.

The principles of learning and teaching assume exist, on the condition that:  
a) learning requires active and constructive participation of the student in activities that demand efficient and flexible strategies and in addition, they help them understand and think logically in activities which set their own learning goals and help them correct their mistakes.

b) New knowledge is constructed better when associated with pre-existing knowledge and organized through the effective understanding and not through memorizing (Wreaths I., Tzelepi S., 2013). In the current society of knowledge, “the cogito ergo sum” of Descartes, I think, therefore I am, should be mutated into “Scio ergo sum”, I know therefore I am (Alachiotis, 2002).

We rely on the basic pedagogical and didactic principle according to which learning is better when incentives and interest are created in learning and in the context of innovative teaching approaches dictated by the curriculum chosen as the subject matter of the project examining the relationship between mathematics and art.

### **Criteria selection**

*"Art reconstructs the relations and the forms of natural or imaginary reality through images and object. Mathematics studies the relations and the forms of natural or imaginary reality. Art creates, visualizes, maths studies".*

*(See <http://mathmosxos.blogspot.gr/Hardy>, 'Apology of Mathematics')*

*"A mathematician, just like a painter or a poet, is a designer. A Painter creates designs with shapes and colors, a poet creates with ideas. Mathematical sketches, like those of the poet or the painter, maths diagrams have to be well- designed. There is no permanent place in the world for bad maths".*

*(See <http://mathmosxos.blogspot.gr/Hardy>, 'Apology of Mathematics')*

Undoubtedly, maths has an element of objectivity and is related with the logical part of humans unlike art which has the element of subjectivity and is mainly related to the emotional part. Art arises as the pure offspring of the human need for expression while Mathematics equally arises as the pure offspring of the human need for understanding, However both needs that differentiate humans from animals coexist in one and indivisible whole: human nature . So, the apparent difference in principle should have connecting bridges.

Art and Maths constitute two of the primary human activities. We have found artifacts (representations on walls of caves, stones, shells and later in more complex structures such as juvenilia jewelry, amulets, etc.) since the dawn of the human civilization. The first mathematical concepts of measurement, calculating distances or sizes are imprinted in primitive forms in samples of settlements dating from 2500 B.C. Therefore, it is a reasonable question: Are Art and maths interwoven concepts? Were they developed simultaneously and independently or is there a deeper way to connect them?

Maths and art in general, although, (seemingly at least,) they constitute two separate - different spheres of human activity, however, they can be combined and provide us with creations which are an admirable blend of impressive complexity and astonishing beauty. It is important to give students an opportunity to explore the ways in which the interaction of maths and art take place throughout centuries. Moreover, mathematics from ancient Greece until today have been playing an important role in the development of various forms of art. In all seasons prominent forms of art have been highlighted, which used mathematics as the key component of their art.

#### **Goals of study in the project:**

For the methodological organization of the study of this project and for a better analysis of the goal the following learning goals have been set:

1. Which is the effect of geometry on various art forms (architecture, painting, sculpture) from ancient Greece to the modern age?
2. In what ways and how the relationship between mathematics and art is manifested?
3. How and in what ways is the interpenetration between expressed math-art?
4. How can we exploit new technologies to build artistic creations with specific geometric properties?

-Reasons of similarity in Figures

-Transformations and symmetries

-Geometric patterns

-Mosaics & paving

-Tessellations

5. How can we be inspired by the art for making artistic creations and constructions?

Why does the beauty of a work of art emerges through the science of mathematics?

#### **METHODOLOGY**

##### **Progress and Implementation steps of the Project**

The students were divided into groups and answered individual research questions. In every encounter through dialogue, exchange of views and arguments, they testified their own ideas about the interaction of mathematics and art. More specifically, the stages in the processing steps of the project were:

##### **Bibliographical review**

The student groups are coordinated for a bibliographic search of information in the school library, internet, scientific articles and journals.

**Team A:** They dealt with the relationship between mathematics and art in the Middle Ages-Renaissance.

**Team B:** They dealt with the gold ratio ( $\phi$ ) and the world of fractals.

**Team C:** They dealt with the Modern art.

Students collected a lot of pictorial material that was to be analyzed and justified through the development of discussion forming arguments, exchanging opinions. Finally, they presented their bibliographical material in the plenary of the class.

The bibliographical review in the Middle Age and the Renaissance revealed aesthetics, harmony and beauty of painting and architecture beneath the strong influence of mathematical precision and geometrical thinking. Gothic architecture and Islamic art have been strongly influenced of mathematics. Artists such as Leonardo da Vinci (1402-1519), Piero della Francesca, Brunelleschi Filippo are known for their achievements both in science and in arts. Other ways of manifesting the relationship between mathematics and art have been examined through the study of gold phi number and its geometrical of structures and “roaming” in the wonderful world of Fractals. The bibliographic journey closes in modern art with the works of Escher and

Vasarely and the mirages and it illustrates that art aesthetic trends along with the logic of mathematics.

### **Using new technologies and properties of mathematics educational software (Sketchpad, geogebra)**

The use of new technologies for the creation of a modern digital art necessitates the exploitation of educational software properties for presentation, construction and testing of artistic constructions, which confirm the strong influence of mathematics in art. The potential of dynamic geometrical software have been exploited and students practiced using and examining technological tools, creating artistic compositions, urging their creative imagination and artistic instinct at the same time.

The students had the opportunity to take the initiative and active role to reveal the interaction of mathematics and art. Using new technologies and educational software of Maths (Sketchpad, geogebra) according to the necessary bibliography and guidance, they created geometrical constructions with specific geometric properties: Reasons of similarity in shapes, transformations and symmetries, geometrical patterns, mosaics and paving (See: <http://youtu.be/WVcjK7nNsA8> and Appendix A) Create artistic creations

Creativity, efficiency and artistic skills of the students were depicted in original manufactures and handicrafts. The sense of beauty and harmony of proportions were cultivated with the opportunities given to students to create geometrical synthesis promoting their creative ability and imagination fabricating decorative patterns using well known geometrical shapes and exploiting their geometrical knowledge. (See: <http://youtu.be/Z30z1jol3Ag> , <http://youtu.be/z-xRCdbu-A8> and Appendix B)

### **Educational visits**

The tour in the world of mathematics in context with the wonderful world of art was completed with experiential activities of students during their educational visits. In the educational program of the Museum Irakleidon (<http://www.herakleidon-art.gr/el/>), which was attended by students, the points where both areas of human thought and expression meet and interact were detected. Emphasizing the geometric period of Greek art, the relationship of Mathematics and Music (Pythagorean scale), the classical art (Parthenon-Proportions-Golden Section), the linear term (Renaissance), the geometry of modern art (Cubism) and finally the modern one called “mathematical art” and self-similarity (fractals). Finally thanks to some appropriately selected works of MC V. Vasarely and Escher and other artists, students discovered and examined the nature and philosophy of important mathematical concepts.

In addition the educational visit to the National Institute of Sciences (<http://www.eduscience.gr/>) mobilized the interest of students with specific scientific constructions and exhibits which are related with concepts and knowledge about the interaction of mathematics and art. Through their interaction with them, the students participated in a dialogue of deeper research and understanding

### **RESULTS-DISCUSSION**

To evaluate the results of the project were collected through questionnaires to pupils’ quantitative and qualitative data during and after implementation. The quantitative and the qualitative analysis showed that, during the didactic application developed positive beliefs and mobilized the students' interest in mathematics and art, created an incentive for deeper understanding of the subject of geometry and understood sufficiently geometry fractals. Creative-critical thinking skills were developed as well as mathematics software for designing complex geometric structures. The positive attitude is explicitly stated in semi structured interviews.

**A) The bibliographical search considered interesting** by the students and achieved the intended objectives of knowledge: Students' responses showed that they were informed about the following topics:

*'The architecture and art in the Renaissance', 'painting in the Middle Ages', 'the works of Leonardo Da Vinci (.... I did not expect to hide so many things)', 'the relationship between art and mathematics in antiquity', 'historical data for the development of art which link everything around us', 'historical data for the development of art and ways of relating everything around us', 'the relationship of the golden section in art', 'appearance the golden section and the golden ratio in the natural world', 'fractal', 'information about the life and work of Escher'.*

All students agreed that there was information that impressed the bibliographic presentation of all groups and gave them the impetus to deal with the backing of their study. The answers are: *'I liked the paintings of Escher and their analysis', 'the golden ratio', 'creations of Escher', 'The evolution of art through time', 'the work of Renaissance', 'the analysis of the drawings was amazing', 'I liked very much the work of Escher and motivated me to look more', 'all groups showed significant projects equally interesting topics such as the golden section and art and math in Middle Ages', 'I particularly liked the presentation made for gold ratio  $\phi$ '.*

**B) Issues mobilized interest and rated 'pleasant'.**

Quantitative content analysis of open responses of students to questions was done: i) what has drawn the interest of the state of implementation of the project, at an intermediate stage of implementation ii) what surprisingly pleasant features and factors are acknowledged project, after the completion.

The following findings were found after encoding and processing of answers: The application of mathematics educational software in the course of implementation of the research fits the data are quite liked by the students. Some of the indicative answers reflected clearly that mathematics educational software have mobilized students' interest and an element of teaching practice that is very positively accepted: *'exploration Sketchpad', 'Sketchpad', 'I learned to design by mathematical software, application geogebra-Sketchpa', 'worked with mathematical software'.*

Also what is very important is that they great frequency growing skills is something unexpectedly pleasant. They state: *'experience', 'extend knowledge', 'knowledge about art and mathematics', 'we learned many things about the relationship between mathematics and art', 'new information, questions for discussion', 'how many things I could learn and eventually I did learned' 'exchange of views'*

**C) The attitudes that the students formed towards the lesson of geometry** is mainly reflected in the qualitative analysis of their responses in interviews. The content analysis of the interviews provides very important information about the contribution of the teaching course of the project in shaping perceptions and positive attitude in the course of geometry, in recognition of the important role of mathematics in everyday life.

They were asked to answer: *'In what way do you think this project has helped you with mathematics'?*

Student 1: *"Through the theories that exist and you can see the geometry, these theories through action we can understand better"*

He continues more specifically: *"For example, when reading for geometry exam were theorems and definitions that helped me to understand very much through the experience I had with the project at project ... I understood the definition of mathematical more deeply"*

Student 2: *"Maths is actually what we have been told since old times that it interprets the world in another language"*

Student 3: *"Specifically, maths is a beautiful study, it has thought, it has a structure, but I like geometry much more ... I like it because now that we have combined it with art I have another view"*

Student 4: *"The goal of mathematics is to open your mind to think about new ideas, solves not only problems, but also helps in life ... If you do not succeed, this will find another way to solve something"*

It is reflected that the project acted as a catalyst in the promotion of the role of mathematical science. But most importantly contributed to the understanding of the geometric theory through the connection of mathematics to art.

But assesses their instructional practices during the course of the project, when students said:

*"Maybe it's the wrong way to approach mathematics are taught ... Through the project we learned to see other aspects of mathematics ... The project helped in the expansion, there could be other courses that would help in further expansion of mathematics »*

*"The teacher plays a very important role in what you see in front of you, what you teach and what you hear depends on how you will receive. That is when the teacher is super and you do not sit and read it will not work»*

## **DISSEMINATION OF ACTIONS AND RESULTS**

The students participated in the 5th International Conference on Mathematics Week in Thessaloniki in March 2013 with the presentation of the project, the promotion of their artistic creations and geometrical structures. Students gained positive experience from the displays of their work while simultaneously evaluates that facilitate and promote the school, as well as enhancing the self-esteem of students.

Additionally the interest and artistic creations of students, by implementing the project, the impetus for the use of visual collaboration Mrs. Lalazisi Ch. (Secondary education consultant) and painter Mr. Mousmoulidi), mathematics (teacher of the school) and the administration of school for aesthetic enhancement of the hall and the surrounding area that will act as a laboratory of Mathematics and simultaneously as an exhibition area for the creativity of students in the school's Evangeliki model school of Smyrna. (See: <http://youtu.be/Ln2OfbW6PRE> and Appendix C).

In this exhibition area for Mathematics and Art prospectively are planning to organize workshops for students and teachers from other schools, where the artistic-mathematical structures will be notified and will present with aim of obtaining new creations and the journey into the world of mathematics and art will continue through mutual feedback.

The team of students who participated in the project coordinated by associate professor of mathematics and the School of Architecture Director actively interacted in Community Schools Europe: 'e-twinning' the implementation of the project

entitled: 'Math and Arts' and 'Tillings in Europe'. With the use of internet communication tools students collaborate, exchange ideas opinions, communicate and publish their work and especially are inspired and derive ideas for further study. At the European level and the president of the European Society for Art and Math Mr. Claude Bruter (<http://www.math-art.eu/>) has published the results of the project on their website ([http://www.math-art.eu/X\\_School.php](http://www.math-art.eu/X_School.php))

The results and conclusions of the project with the topic: "Mathematics and Art" have been screened by Mrs Argyris P. and Mrs. Lalazisi Ch. in conferences:

- i) 10 National Conference of School Directors on: 'Illuminating of teaching: Modern teaching implications ', Corinth December 4, 2013, (<http://www.pess.gr/draseis/synedria.html>)
- ii) 5th Conference of the Investigators of Mathematics on: ' Mathematics in school and in everyday life 'Florina 13-15 March 2014 (<http://enedim2014.web.uowm.gr/>)
- iii) Conference of model schools on the subject: "Mathematics Standards schools, Possibilities and Prospectives", Athens, 8 Απριλίου 2014, (<http://mathlab.mysch.gr/synedrio2014/parousiaseis>).

**The full text of the project is published in the school website:**

[http://lykevag.att.sch.gr/autosch/joomla15/images/Ergasies/Projects/2012\\_2013/Argyri/MarhimatikaKaiTexni.pdf](http://lykevag.att.sch.gr/autosch/joomla15/images/Ergasies/Projects/2012_2013/Argyri/MarhimatikaKaiTexni.pdf)

### **THANKS**

*Mr Metaxas N.*(mathematician in Gymnasio Evangelikis Model School of Smyrna), who was present in all study subjects of project, actively participated in the implementation phases of project, collaborated creatively with groups of students, provided the scientific knowledge, provided the scientific knowledge gave necessary directions to review the information processing bibliography, helped indecisively and increased learning and teaching results of project.

*Mrs. Architecture Lalazisi Ch.* contributed greatly to the realization of the project, giving students the necessary instructions and guidelines for the creation of artistic construction. Moreover it successfully evaluated the results of project through experimental research actions which were carried out.

*The manager of school* supported the ambitious and innovative design project. The available material resources contributed to the creation of the artistic creations of students. In the same time there was adequate logistical infrastructure, so that students have the ability to use computers and a specific workplace to produce their projects. Furthermore, *the Teachers Association and the Parents Association* supported the realization of live visits students at the Museum Irakleidon and Institute Sciences.

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Ministry of Education, Lifelong Learning and Religious (2011) Proposal for the New School. ([http://paspif.gr/wp-content/uploads/2011/07/neo\\_lykeio.pdf](http://paspif.gr/wp-content/uploads/2011/07/neo_lykeio.pdf))

Pedagogical Institute, *'Proposals for Interdisciplinary Unified Framework Curricula and Curricula Compulsory Education'*, 2004. (<http://www.pi-schools.gr/programs/depps>, access May 2006).

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### **Resources for lesson study in project**

<http://nrich.maths.org/6809>, <http://nrich.maths.org/7002>,

[http://www.motivate.maths.org/conferences/conf19/c19\\_intro.shtml](http://www.motivate.maths.org/conferences/conf19/c19_intro.shtml),

<http://www.scribd.com/doc/2826497/Math-and-Art-by-audre-WeirdArtscom>,

<http://www.math.lsu.edu/~verrill/origami/sonobe/>,

<http://britton.disted.camosun.bc.ca/jbpolyhedra.htm>,

[http://www.astro-logix.com/index.php?main\\_page=models&pages=1](http://www.astro-logix.com/index.php?main_page=models&pages=1),

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<http://www.smashingmagazine.com/2008/10/17/50-phenomenal-fractal-art-pictures/>,

<http://browse.deviantart.com/digitalart/fractals/>,

<http://www.fractalpainting.com/>,

<http://www.fractalfieldpainting.com/>,

<http://wni.math.u-szeged.hu/chaos/doku.php>,

<http://cjain.free.fr/enpage.php>,

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[http://www.fractsurf.de/e\\_index2.html](http://www.fractsurf.de/e_index2.html),

<http://www.gameprogrammer.com/fractal.html#install>,

<http://www.ultrafractal.com/>,

<http://www.brotherstechnology.com/math/fractal-music.html>,

<http://www.ntua.gr/arch/geometry/mbk/anamorpheis.htm>

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[http://morfologia.arch.duth.gr/1o\\_etos/pdf/prooptiki.pdf](http://morfologia.arch.duth.gr/1o_etos/pdf/prooptiki.pdf)

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<http://www.p-theodoropoulos.gr/Escher.htm>

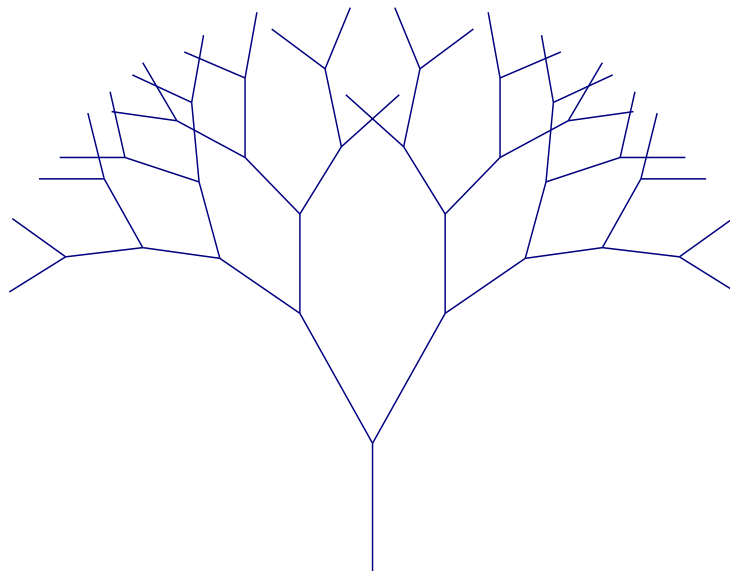
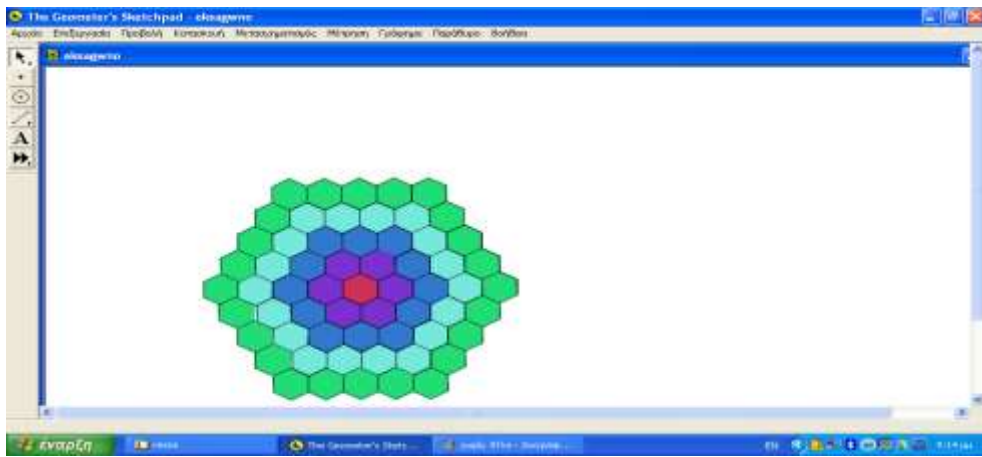
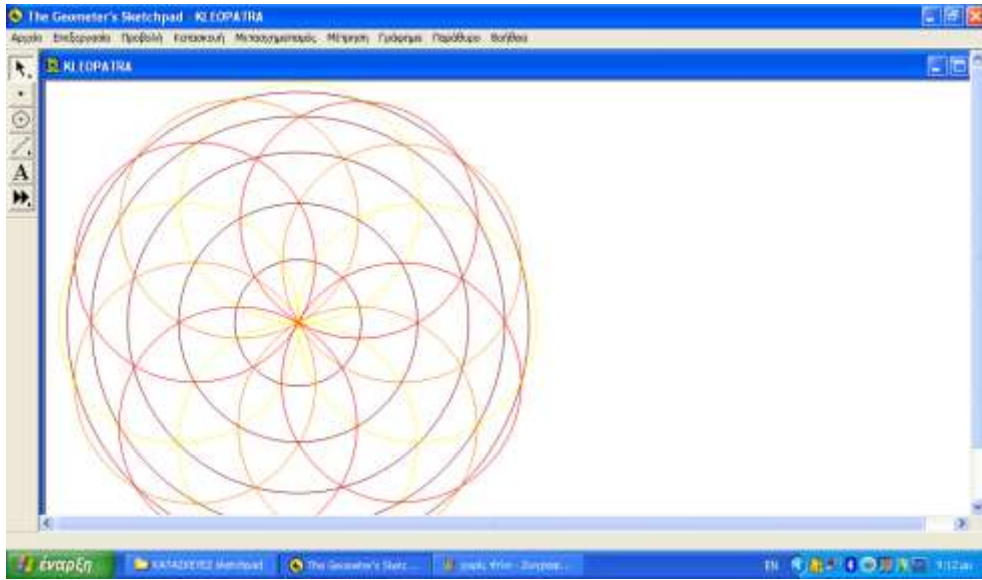
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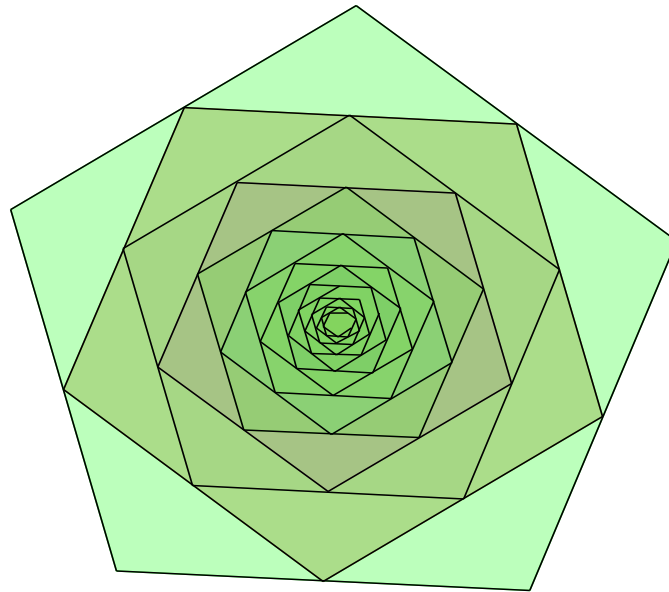
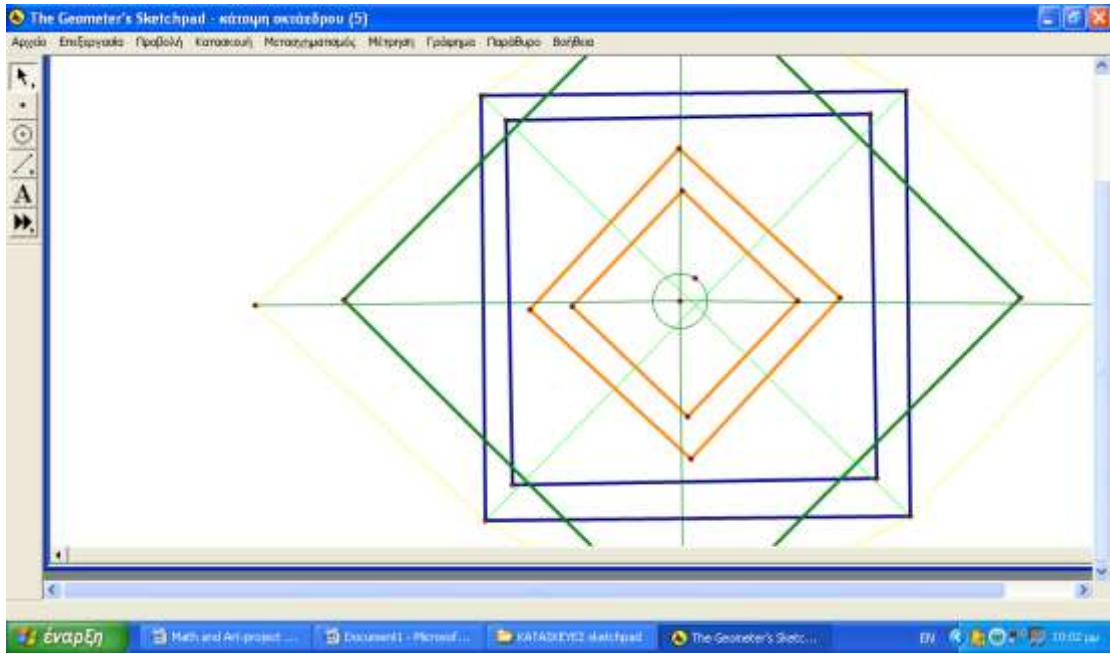
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<http://roadartist.blogspot.gr/2009/05/mcescher-1898-1972-escher-282009.html>  
<http://kokiniklwstidemeni.blogspot.gr/2009/07/escher.html>  
[www.isama.org](http://www.isama.org) (*International Society of Arts, Mathematics and Architecture*).  
[www.math-art.eu](http://www.math-art.eu) (*European Society for Mathematics and Art*).  
[www.artlex.com](http://www.artlex.com) (*Definition of mathematics in relation to visual arts*)  
[www.math.nus.edu.sg/aslaksen/teaching/math-art-arch.shtml](http://www.math.nus.edu.sg/aslaksen/teaching/math-art-arch.shtml) (*National University of Singapore's course on Mathematics in Art and Architecture*)  
[www.goldenmuseum.com/0305\\_GreekArt-engl.html](http://www.goldenmuseum.com/0305_GreekArt-engl.html).  
[www.fractalsciencekit.com](http://www.fractalsciencekit.com).  
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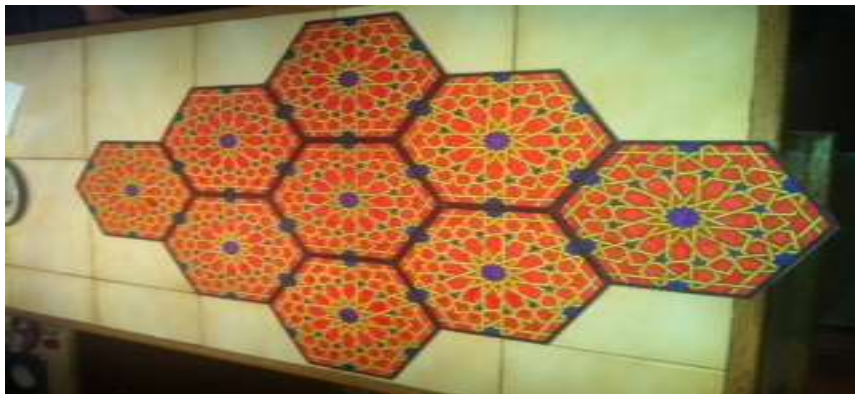
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## APPENDIX A

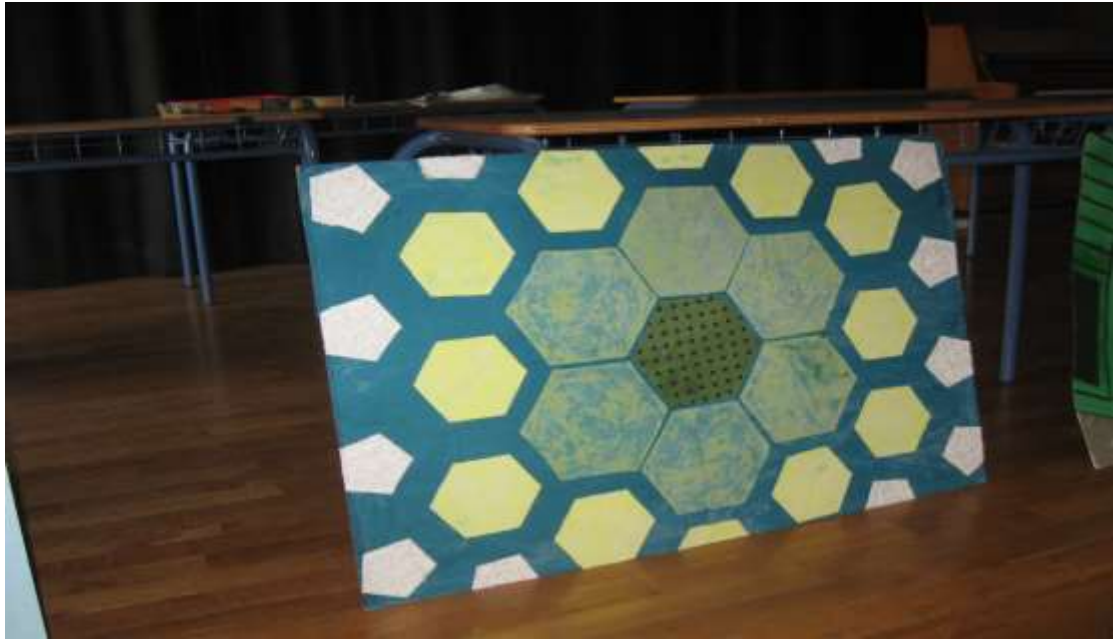




(<http://youtu.be/WVcjK7nNsA8> )







(<http://youtu.be/Z30z1jol3Ag> , <http://youtu.be/z-xRCdbu-A8>)

APPENXIX C





(<http://youtu.be/Ln2OfbW6PRE>)

**This paper presents the methodology and results of the implementation of the Project in Lykeio Evangelikis Model School of Smyrna in Greece during the school year 2012-13 on “The interaction of mathematics and art from ancient Greece to the 21st century”.**

**We hope participants in conference interesting in the interaction in Math and Art.**

**So, we would like to work with teachers and students from schools in Europe and share ideas and experiences in Scientix platform.**

**We would to share students' work and study in using ICT according to bibliography for making creations with potential of dynamic geometrical software. Also, we present photos in original manufactures and handicrafts that creativity, efficiency and artistic skills of the students were depicted. All creations are exhibited in a classroom of school and the main goal is to mobilize students' interests about math.**

**(We have included reference and resourses,that we used for implementation of results of project 'Math and Art').**

**(Thanks: Mr Metaxas N.(mathematician in Gymnasio Evangelikis Model School of Smyrna), who was present in all study subjects of project, actively participated in the implementation phases of project).**

# PANAGIOTA ARGYRI

[\(Edit\)](#)

Email Address:

argiry@gmail.com

Job Title:

Mathematician in Lykeio Evangelikis model school of Smyrna

## Questions

### Registrant Information

Please select the session you want to apply for: Presentations

Title of talk: MATH AND ART

Submit your abstract (PDF): Math and Art-Project for presentation in Conf.pdf

Target Audience: Teachers, Other: Students

Please select your country: Greece

If you have any comments you would like to share with us in advance, please let us know here: This paper presents the methodology and results of the implementation of the Project in Lykeio Evangelikis Model School of Smyrna in Greece during the school year 2012-13 on "The interaction of mathematics and art from ancient Greece to the 21st century". We hope participants in conference interesting in the interaction in Math and Art. So, we would like to work with teachers and students from schools in Europe and share ideas and experiences in Scientix platform. We would to share students' work and study in using ICT according to bibliography for making creations with potential of dynamic geometrical software. Also, we present photos in original manufactures and handicrafts that creativity, efficiency and artistic skills of the students were depicted. All creations are exhibited in a classroom of school and the main goal is to mobilize students' interests about math. (We have included reference and resources, that we used for implementation of results of project 'Math and Art'). (Thanks: Mr Metaxas N. (mathematician in Gymnasio Evangelikis Model School of Smyrna), who was present in all study subjects of project, actively participated in the implementation phases of project).

## Agenda

### Agenda Items

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