

Fostering the art of scientific discovery in gifted children

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16.08.2019, FRIB, MSU, East Lansing

About me “in a nut shell”

- At home I check on daily basis if I am mathematician according to **Paul Erdős**:

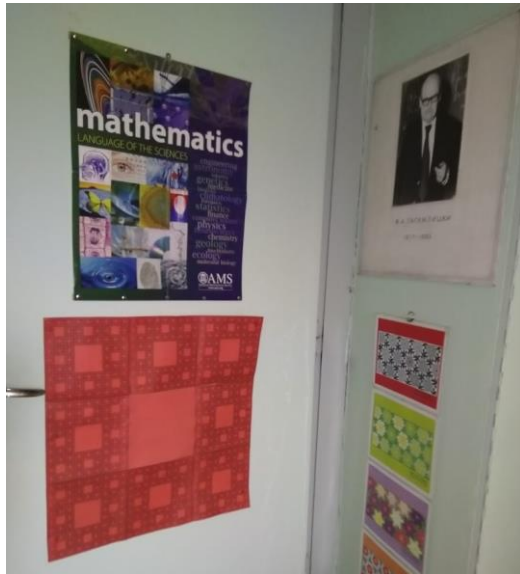
A mathematician is a device for turning coffee into theorems.



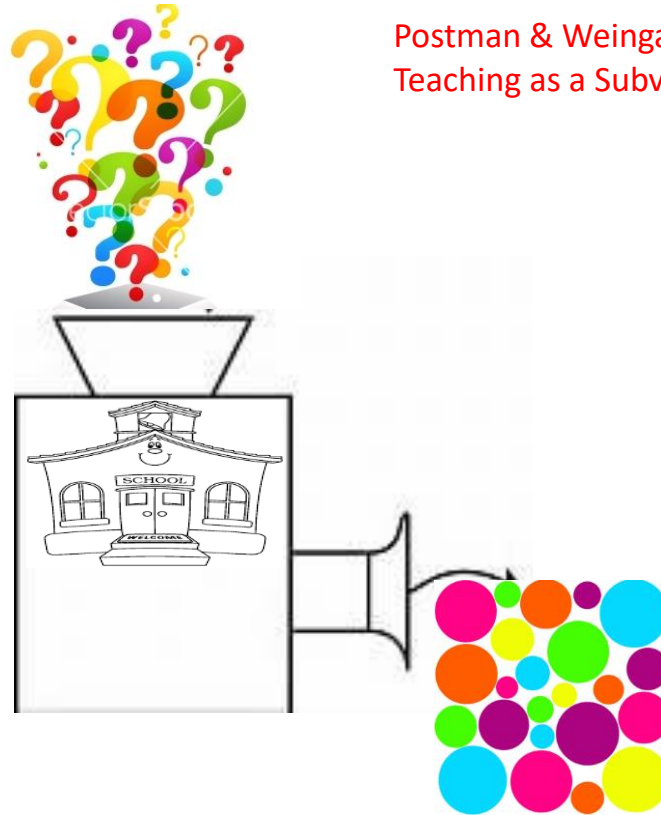
- My students range from 6 to 66



My office at IMI-BAS



*The kids enter **school** as question marks and
leave as periods.*



Postman & Weingartner, 1969:
Teaching as a Subversive Activity

The importance of keeping kids as
question marks

What does Dudley Herschbach think?

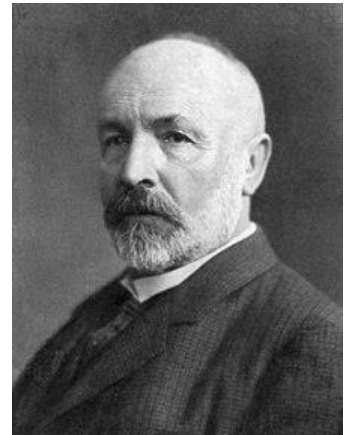
(1986 - Nobel prize in chemistry):

The small difference between the student and the scientist is how they react to a question they don't know the answer to.



A title of a doctoral thesis

In mathematics the art of asking questions is more valuable than solving problems.



Georg Cantor
1845 – 1918¹

Too often we
prefer tests

(with multiple
choice of
answers at that)!

$$1/2 + 1/3 = 1/5$$

- A) True.
- B) False.
- C) Who cares?



But...life is not about knowing the right answer, it is about getting things to work, about finding the best way to express one's creative ideas. ...

*It is better to teach children to **act as scientists** instead of teaching them about science!*



Seymour Papert (1928-2016)

We need learning environments in which the students can ask questions and look for the answer with their teachers as partners in a research team.



The *Research Group on Education* Experiment in Bulgaria (1979 – 1990)



1984 – a class in Language and Mathematics

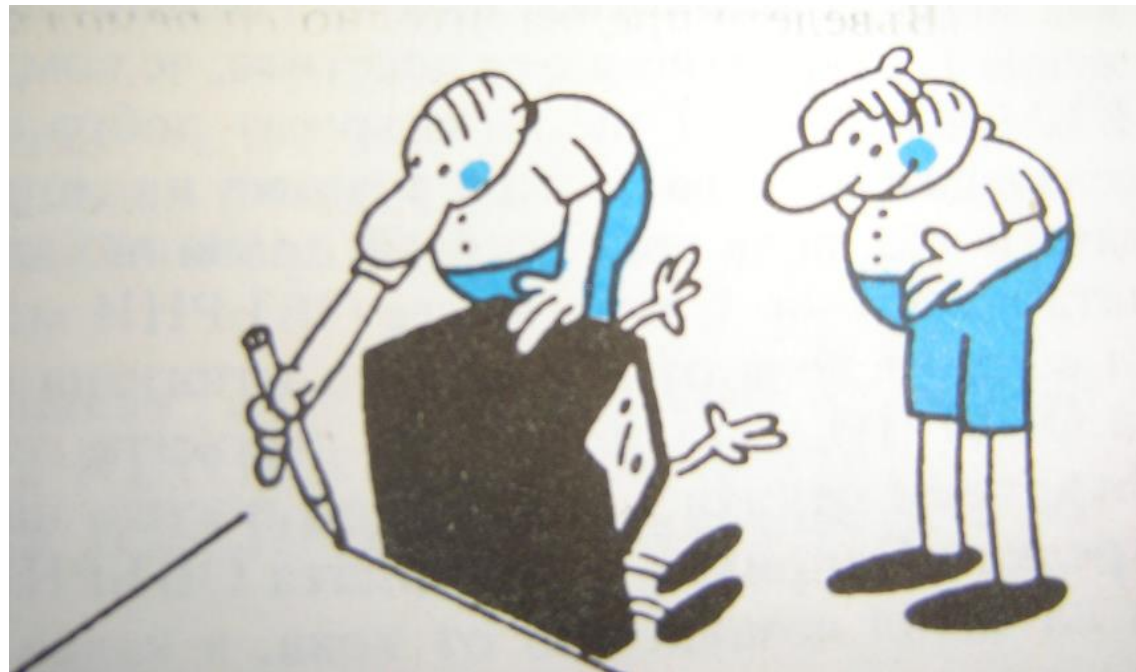
Computers become
a unifying environment for:

- *Integration of school subjects*
- *learning by doing and discovering*



*There is a world of difference between **what computers can do** and **what society will choose to do with them...***

Papert



Drawing a triangle using only... a computer

From *Informatics for beginners* – a textbook by R. Nikolov and E. Sendova, Artist D. Donev

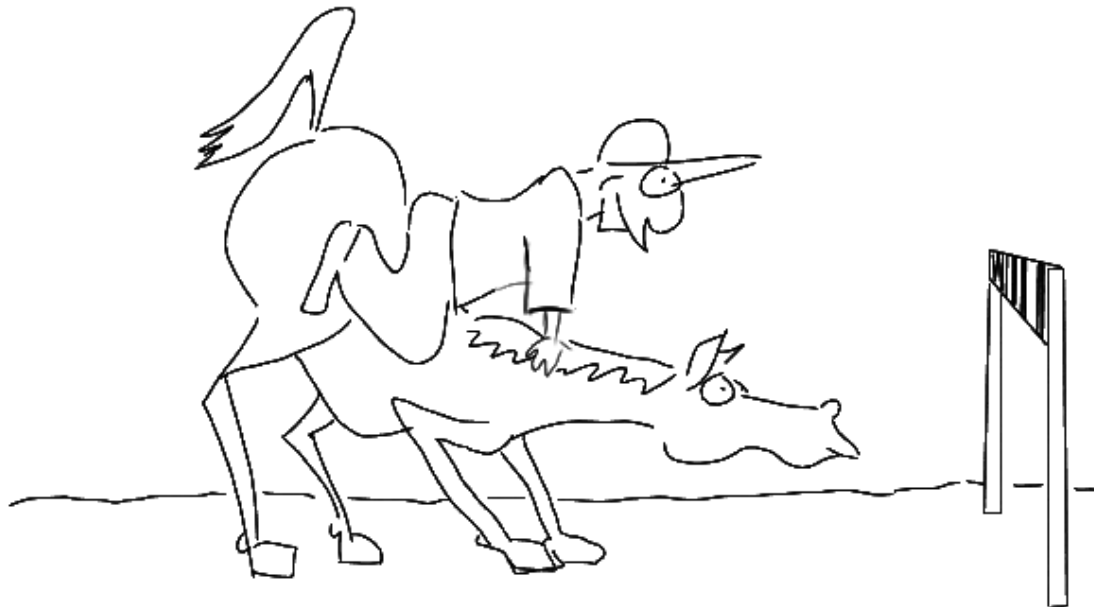
Creating and developing GEOMLAND (a Logo-based computer microworld)

In this *Land of Euclidean geometry*:

- students mastered their mathematical language; they looked for patterns, formulated hypotheses, posed problems and were highly motivated to prove *their own theorems*
- teachers who otherwise would hardly dare to act like researchers felt empowered.

What did the RGE project leader think?

The current evaluation tools are not relevant: we are preparing the students for the Kentucky Turfway Race, and society tests them in steeplechase in athletics...



Cartoon by Yovko Kolarov

Principles that outlasted the RGE experiment and were reborn in a number of EU projects

- Digital Technologies are a means for self-expression, not an object of education
- Learning by doing – students construct something which is meaningful to them and could be shared



Fostering the interest in science from a European perspective

Scientix - the community of Science Education in Europe

<http://www.scientix.eu>



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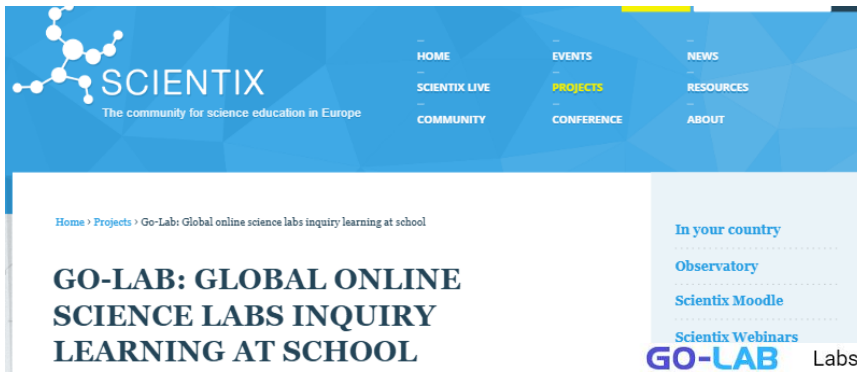
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GO-Lab: online science labs

<http://www.go-lab-project.eu>



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GO-LAB: GLOBAL ONLINE SCIENCE LABS INQUIRY LEARNING AT SCHOOL

Share this project

BASIC INFORMATION

RESEARCH INFORMATION

TEACHER INFORMATION



GO-LAB

Go-Lab (2012 -2016) creates an infrastructure (the Go-Lab Portal) to provide access to online laboratories run by research centres and universities worldwide.

These online labs can be used by universities, schools, instructors, students and lifelong learners to extend regular learning activities with scientific experiments, giving students a real experience of research work.

The Go-Lab Project offers a federation of remote laboratories, virtual experiments, and data-sets (together referred to as "online labs"), as well as facilities for teachers to embed these online labs in pedagogically structured learning spaces.

Go-Lab provides teachers with pedagogical and technical plug (ease of integration), play (ease of use), and share (ease of consolidation) methodologies and infrastructures. The Go-Lab environment will:

- Allow teacher to create dedicated learning spaces;
- Provide access to resources supporting the development of realistic and engaging classroom activities;
- Facilitate networking and exchanging these activities through an online community.

Go-Lab's resources come from large scientific organisations, universities and research institutions, as well as from dedicated companies. Go-Lab offers these lab-owners to easily plug their real experiments online and construct their virtual didactic counterparts.

To further support teachers in using online labs, Go-Lab offers workshops to introduce online virtual experiments and remote laboratories as well as inquiry-based science teaching techniques.

Sharing and Authoring Platform

Find the largest collection of online labs, try-out interactive inquiry apps, combine labs and apps into Inquiry Learning Spaces, and share these with your students and colleagues.



LAB



Electrical Circuit Lab

In the Electrical Circuit Lab students can create their own electrical circuits...

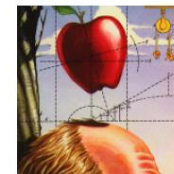
APP



Hypothesis Scratchpad

The Hypothesis Scratchpad helps learners formulate hypotheses.

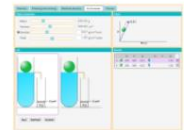
LAB



Gravity Force Lab

This lab allows the user to visualise the gravitational force that two objects...

LAB



Splash: Virtual Buoyancy Laboratory

In Splash students can create objects from object properties like mass, volume...

BASIC INFORMATION



IMI-BAS as a National contact point for Scientix

IMI-BAS and Scientix



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The community for science education in Europe



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VIRMathLAB, VIRTUAL MATHEMATICS LABORATORY

30/04/2018

The Virtual Mathematics Laboratory, VirMathLab, is developed in support of inquiry-based mathematics education and in broader contexts within the fields of Science, Technology, Engineering, Arts and Mathematics (STEAM).

[Read more ...](#)



MASCIL: MATHEMATICS AND SCIENCE FOR LIFE

12/05/2014

MASCIL (2013-2016) aims to connect inquiry-based science and mathematics education (IBSE) in schools with students' future careers and increase their interest in careers in science and technology.

[Read more ...](#)



STEM PD NET, EUROPEAN STEM PROFESSIONAL DEVELOPMENT CENTRE NETWORK

13/02/2018

STEM PD Net (2016-2019) is an innovative Erasmus+ project meant to strengthen European collaboration and exchanges among STEM Professional Development Centres in Europe. The project provides selected materials of highest quality to support STEM Professional Development (PD) and develops guidelines and reference materials that are ready-to-use for STEM PD providers across Europe. Furthermore, among the key targets of STEM PD Net is to reflect and promote the organisational development of the centres in each national context and to strengthen the voice of these centres throughout Europe.

[Read more ...](#)



KEYCOMATH: DEVELOPING KEY COMPETENCES BY MATHEMATICS EDUCATION

25/03/2014

KeyCoMath aims at the development of students' key competences in primary and secondary schools through mathematics education.

[Read more ...](#)



MATH2EARTH – BRINGING MATHEMATICS TO EARTH

13/12/2012

Math2Earth supports teaching and learning mathematics in primary and secondary school by connecting mathematical concepts to our everyday life.

[Read more ...](#)



FIBONACCI - DISSEMINATING INQUIRY-BASED SCIENCE AND MATHEMATICS EDUCATION IN EUROPE

04/05/2010

Design, implement, test and formalise a process of dissemination of inquiry-based teaching and learning methods in science and maths in Europe.

[Read more ...](#)



INNOMATHED: INNOVATIONS IN MATHEMATICS EDUCATION ON EUROPEAN LEVEL

17/11/2010

InnoMathEd aims to develop pupils' key competences and their ability to use ICT for learning processes in mathematics.



DYNAMAT: DYNAMICAL AND CREATIVE MATHEMATICS USING ICT

12/12/2012

DynaMAT focused on a dynamical approach to various mathematical topics, suitable for secondary schools and mathematics teacher training.

[Read more ...](#)




VIVA COGNITA

30/09/2015

Competitions organized by IMI-BAS on the Scientix platform


TEACHING MATERIALS | REPORTS LIBRARY | TRAINING COURSES | LRE MATERIALS

89 RESULTS FOUND.



Sweets, tea and chairs

Descriptor: *information and communications technology (ICT)*
mathematics software

Copyright:  **Age:** 11 - 18 **Project:** *Viva Cognita*


Description: *In this activity, students work on different kinds and quantities of pieces of different items and learn how many they could be using Geogebra.*

★ ★ ★ ★ ★

♥ Add to favourites


🔔 Report a problem

DESCRIPTION GET THIS RESOURCE



Viva Mathematica Competition – 2015/04: 12th grade

Descriptor: *information and communications technology (ICT)*
mathematics software

Copyright:  **Age:** 17 - 19 **Project:** *Viva Cognita*

Description: *10 problems for 12th grade (most of them accompanied by a Geogebra-file), to be solved by different sources by solver's preference - as the case with a specific problem in everyday life may be.*

★ ★ ★ ★ ★

♥ Add to favourites

🔔 Report a problem

SERVICE

Get **free** translation of learning resource materials in the Scientix repository

HOW IT WORKS

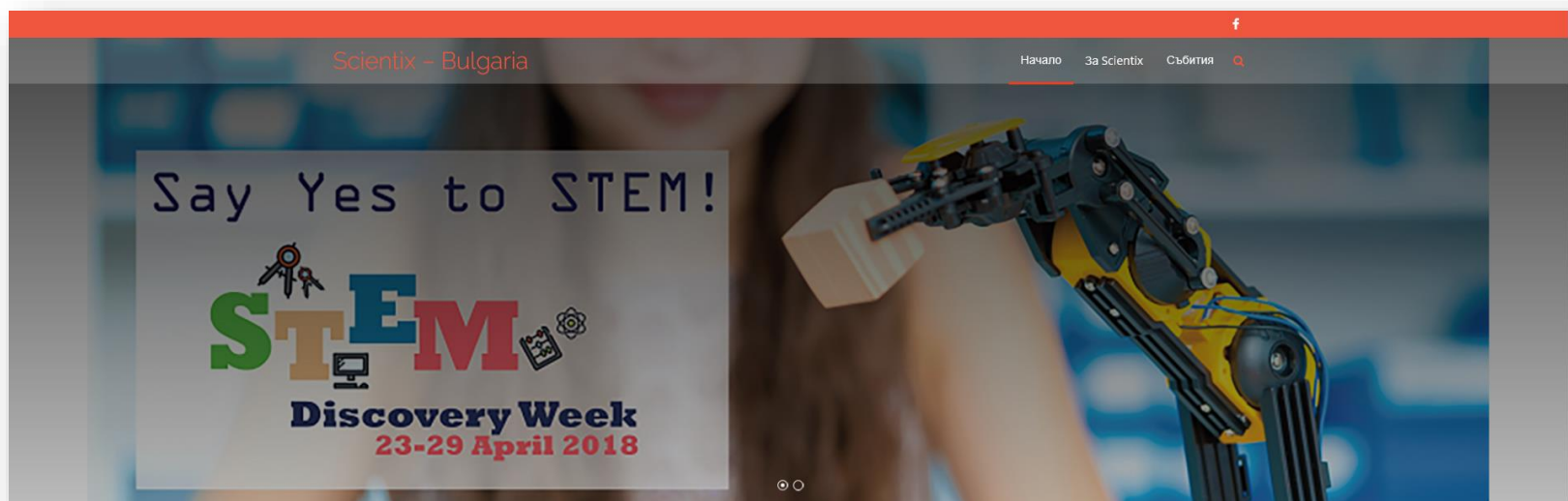
STATUS OF THE REQUESTS

OTHER REPOSITORIES

- Learning Resource Exchange for Schools
- Open Discovery Space



Mathematics in the world around me – an event at IMI-BAS within the STEM Discovery Week 2018



IBL – what is this?

Levels of Inquiry-Based Learning

- *Confirmation inquiry*
The object is confirming well-known results
- *Structured inquiry*
The students explore a problem set by the teachers by means of known procedure
- *Guided inquiry*
The students explore a problem set by the teachers by means of a method of their own
- *Open inquiry*
The students explore their own open problem

Some examples

In the *Virtual Math Lab* of IMI-BAS



Виртуален училищен кабинет по математика

ДИНАМИЧНИ РЕСУРСИ | НАЧАЛО | ТЕСТОВЕ | ПУБЛИКАЦИИ | ЕТЮДИ | СЪБИТИЯ | ВРЪЗКИ | ЗА НАС | ОТЗВИ

ПРЕДУЧИЛИЩЕ | БРОЙ ЗАДАЧИ НА САЙТА - 904 | Търсене

1 2 3 4 5 6 7 8

- ЧИСЛА 1
- ФИГУРИ 1
- ИЗМЕРВАНЕ
- ЧИСЛА 2
- ФИГУРИ 2
- ТЕЛА
- ЧИСЛА 3
- ФИГУРИ 3
- ФУНКЦИИ
- ПРЕОБРАЗУВАНИЯ
- СТАТИСТИКА
- ДРУГИ
- ПЪЗЕЛИ
- ИГРИ
- ИЗКУСТВО

Рисувай-свободна ръка	Рисувай-свободна ръка	Рисувай-свободна ръка
.ggb Пусни като Java аplet	.ggb Пусни като Java аplet	.ggb Пусни като Java аplet
Ротационна симетрия	style Andy Warhol	style Andy Warhol
.ggb Пусни като Java аplet	.ggb Пусни като Java аplet	.ggb Пусни като Java аplet
style Andy Warhol	style Andy Warhol	style Andy Warhol
.ggb Пусни като Java аplet	.ggb Пусни като Java аplet	.ggb Пусни като Java аplet

ИМИ - БАН, секция "Образование по математика и информатика" © 2013

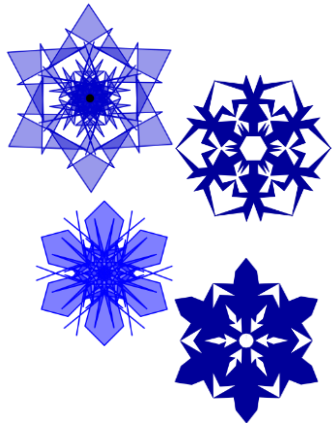
<http://cabinet.bg/content/bg/html/d25004.html>

$k = 15$

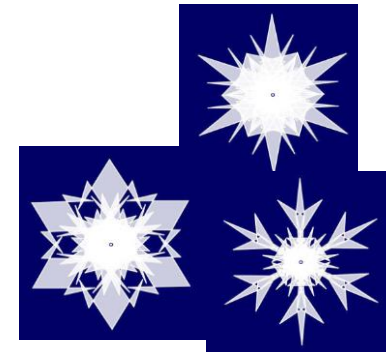
A complex geometric fractal drawing featuring a central white circle with a green dot. The drawing is composed of numerous overlapping, semi-transparent shapes in shades of purple, blue, and green, all contained within a large pink circular frame. The shapes are arranged in a highly symmetric, star-like pattern. The background is a light pink color with a grid of thin lines.

Are there identical snowflakes? How are they alike?

<http://www.math.bas.bg/omi/mascil/resourcesEN.html>



A screenshot of a software interface showing a grid of snowflake fractals. The interface has a dark blue header with a search bar containing 'snowfl' and a navigation bar with numbers 1 through 12. Below the header is a grid of 12 snowflake fractals, each with a title and a file extension. The first two rows contain three snowflakes each, and the third row contains three snowflakes. The titles are 'SNOWFLAKE' in red, and the file extensions are '.ggb' in blue. The third snowflake in the third row is titled 'KOCH PARQUETING' and has a file extension of '.ggb'. The interface also shows a small 'SN' label in the bottom right corner of the grid.



<http://cabinet.bg/content/en/html/d22053.html>

Explorations *à la* M.C. Escher



M. C. Escher



In the junior high school

Playing Escher

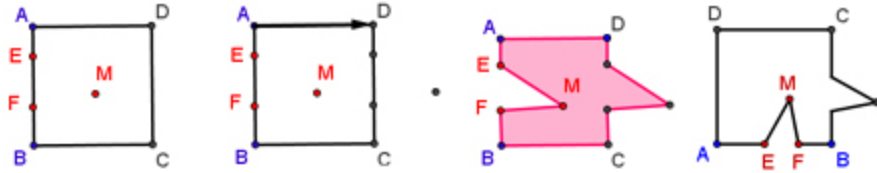
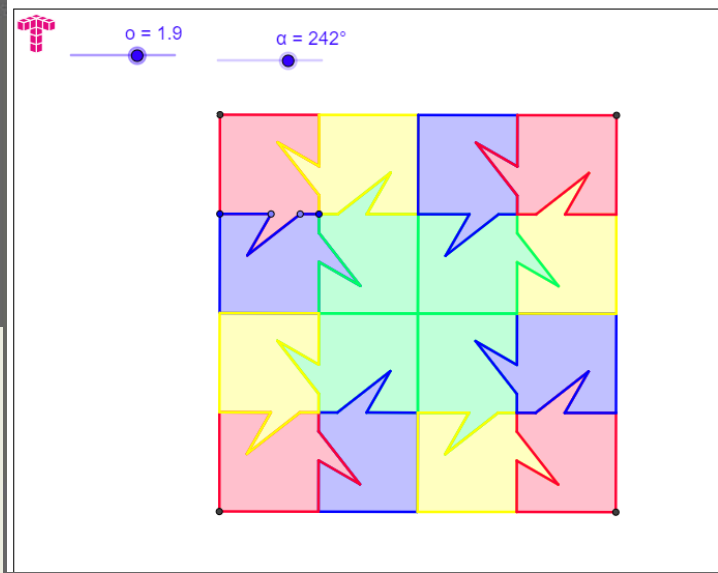
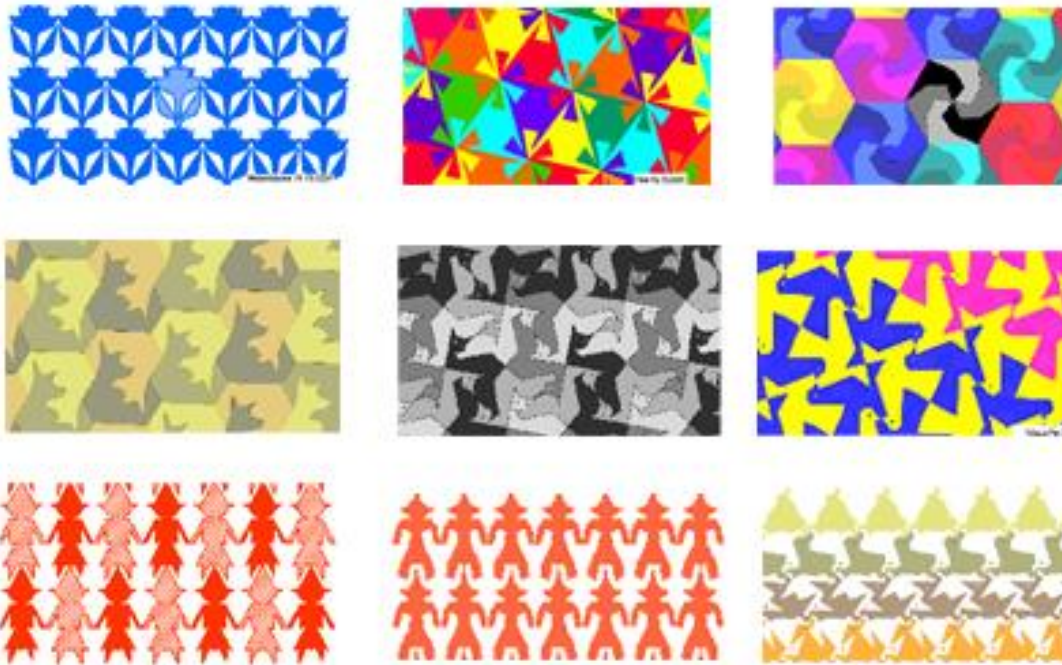


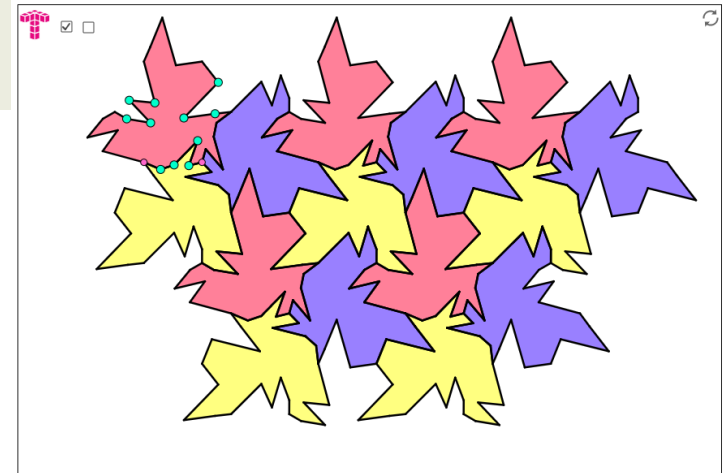
Figure 1. Transforming a square into newly shaped tiles



<http://cabinet.bg/content/bg/html/d25202.html>

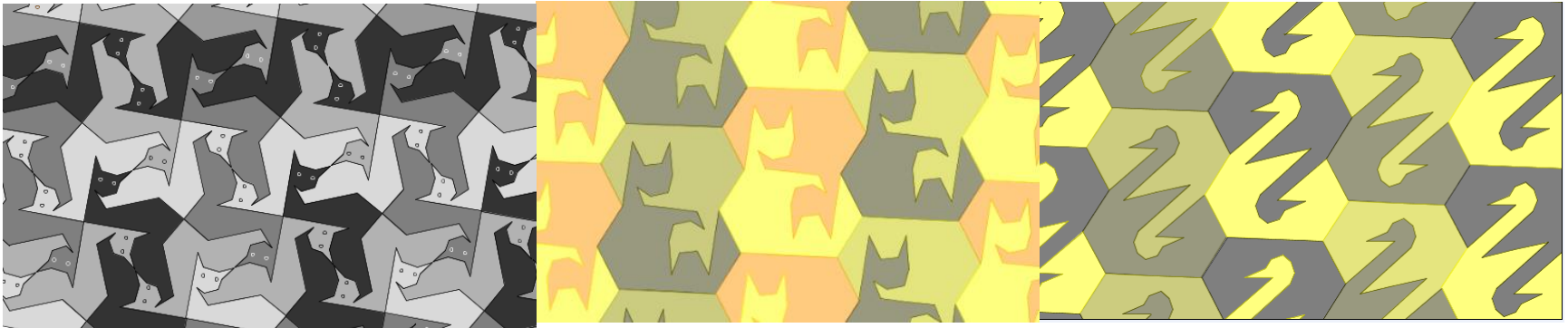
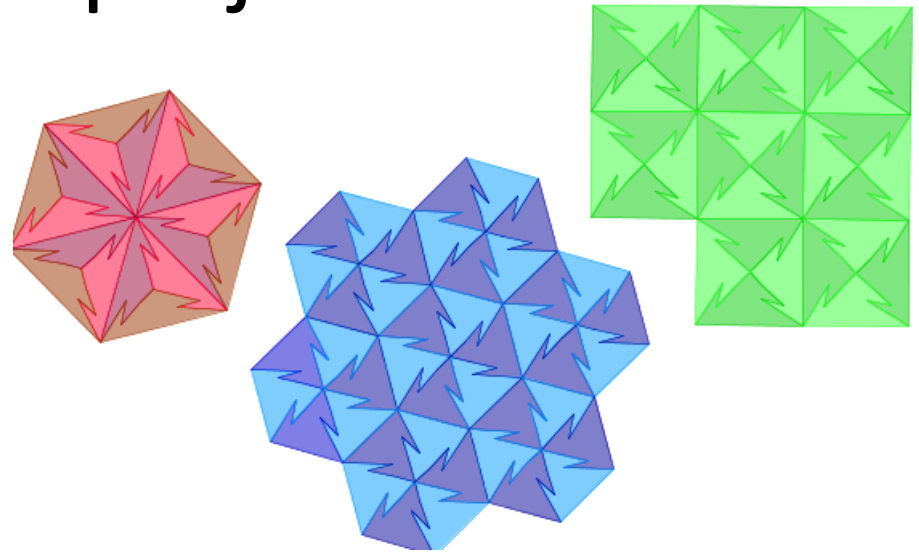


20.8.2019 I.

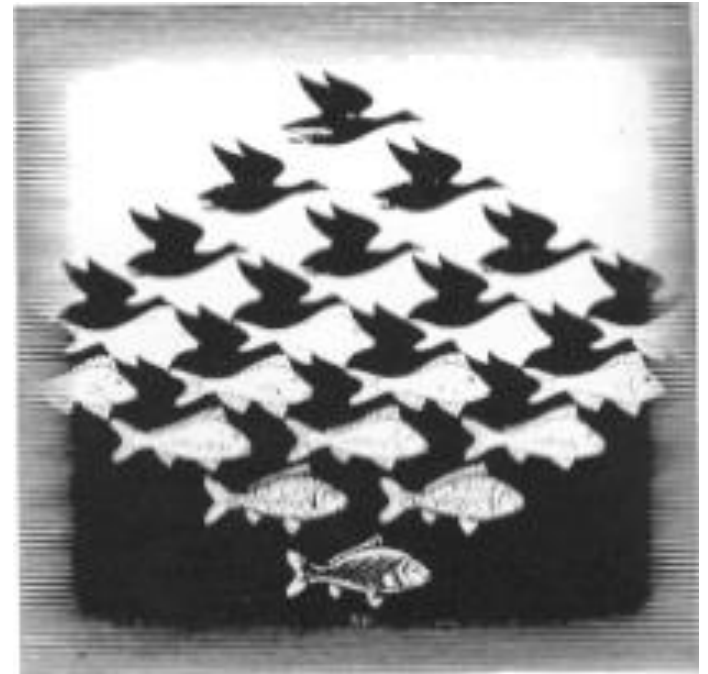
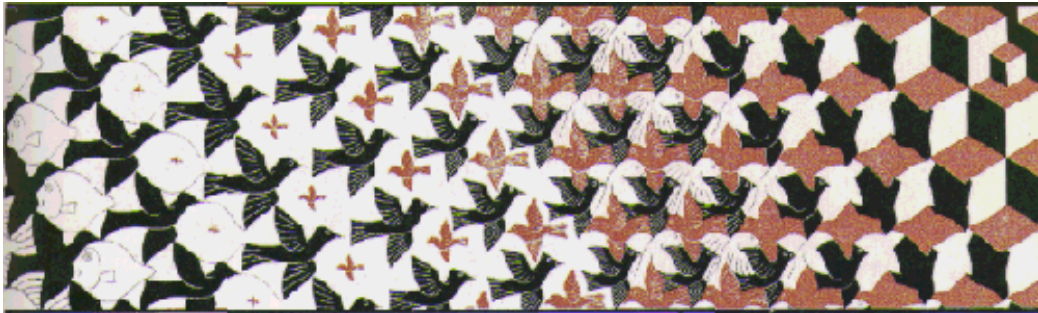


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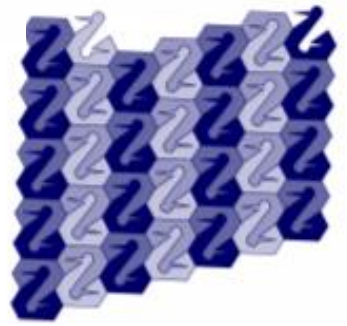
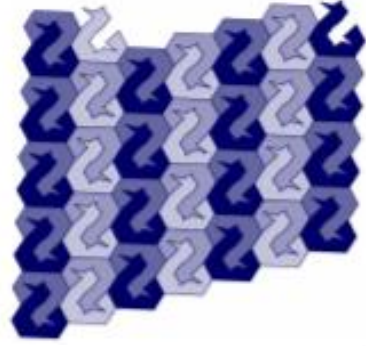
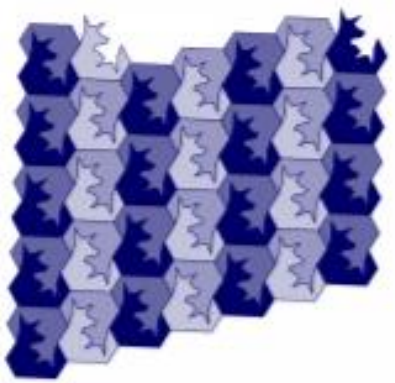
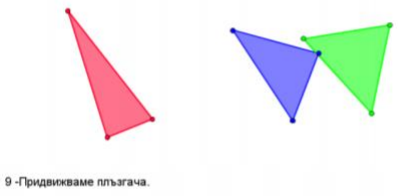
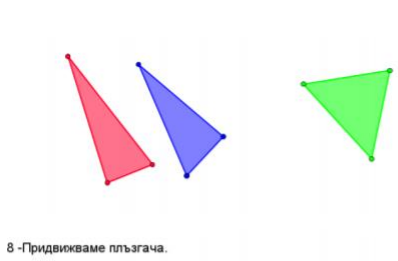
Stimulating students to create their own Escher-like projects



A further challenge: *Can you construct digital metamorphoses?*



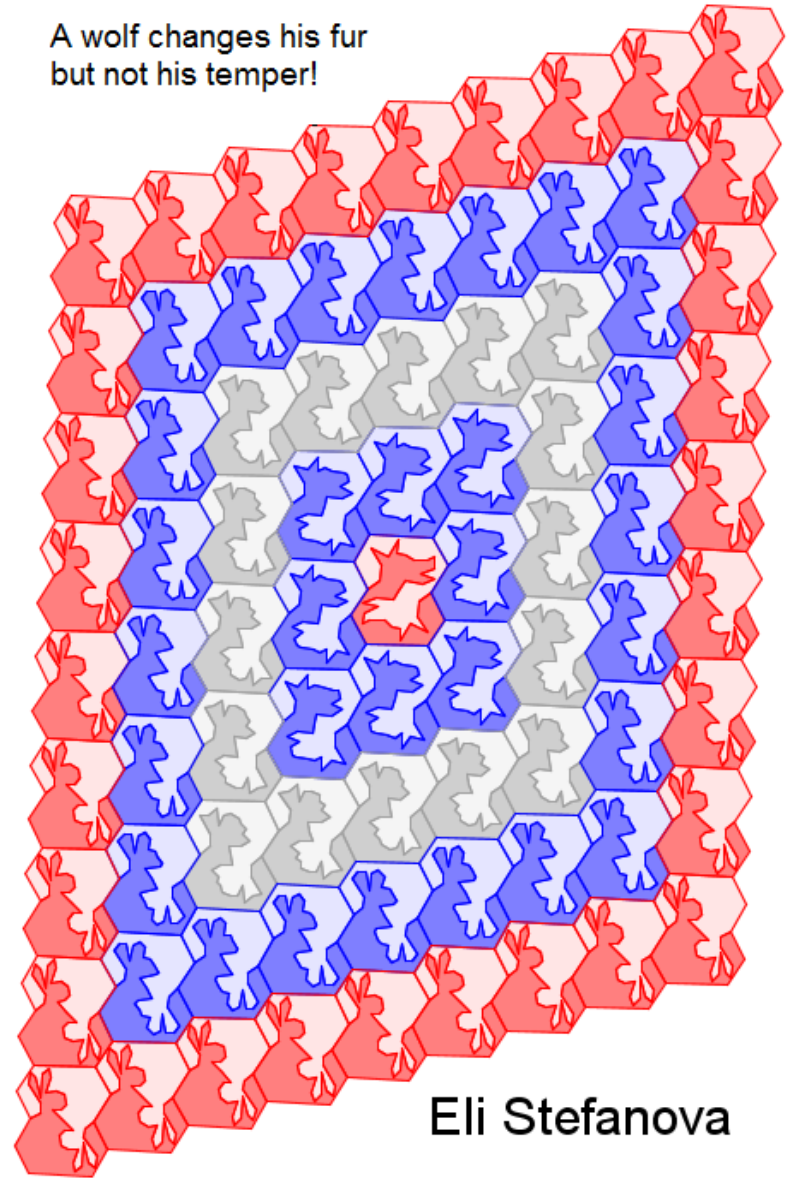
The students: *Why not start from triangles, and then – we'll see...*



Metamorphoses in the style of Escher



A wolf changes his fur
but not his temper!



Eli Stefanova



Dr. Mark Saul: *Creativity occurs on all levels of giftedness, from the lowest to the highest.*

And, as educators, we need to foster and value creativity wherever we find it.

 Thank you!

