

# MindTrainer: intelligence trainers

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## Abstract

We present an interactive web-based system of trainers for testing and development of intellectual skills. Try <https://beta.mindtrainer.ru>. The site helps to conduct offline and online mathematical olympiads for schoolchildren and students. It may also be interesting to math professionals. The trainers invite the user to solve easy to understand mathematical problems with complexity varied from simple to impossible.

## Objectives

Create a product designed for:

- Scientific researches.
- Hosting intellectual Olympiads.
- Creating a collection of interesting puzzles.
- Preparation of methodological materials for math lessons.
- Automatic compilation of sets of olympiad problems for primary school children.
- Popularization of mathematics.
- Intelligence training.

Conduct a study:

- Examine types of tasks.
- Find algorithms to generate them.

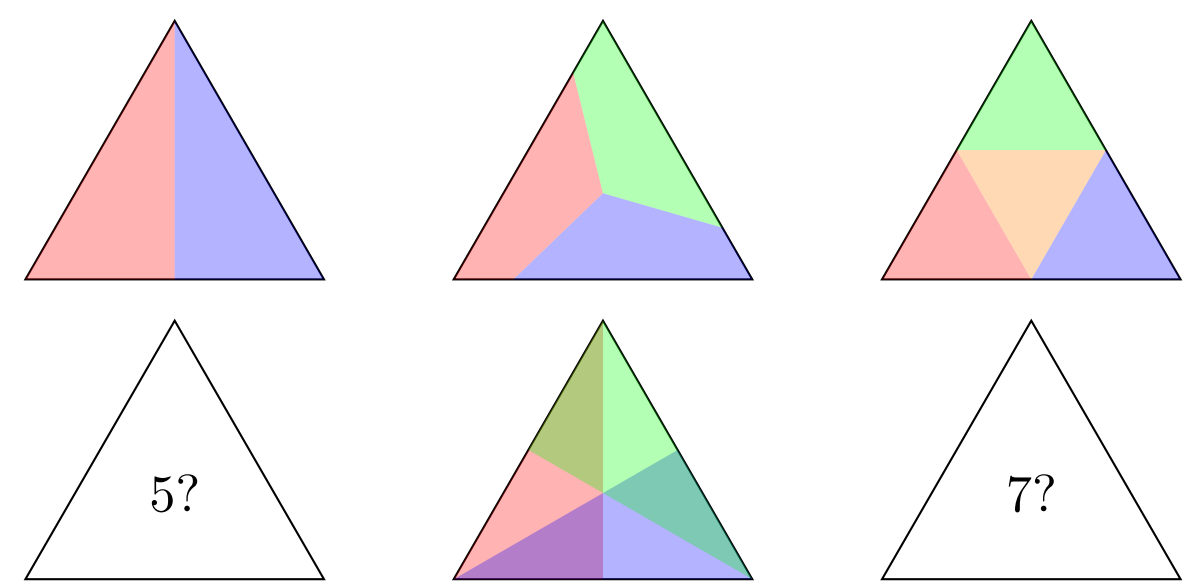
## Introduction

Everyone once tried to solve a bus ticket. The problem is easy: the ticket number is six random digits, your task is to place arithmetic operations between the digits so as to get a predefined result, say one hundred. For instance:

$$573627 \Rightarrow 57/3 \times 6 - 2 \times 7 = 100$$

Most people need a minute or two to solve such puzzle, but some people can do this momentarily. The puzzle can be made more difficult: take more digits, allow parentheses, allow square root and other operations. As the difficulty increases, fewer people can solve it, which puts a basis for competition. Given a sequence of problems of increasing difficulty, how many people can proceed solving them?

When trying to solve a problem, a curious mind not always follows the rules, it challenges the formulation itself. Have you ever tried to cut a figure into several *equal* parts? Try to cut an equilateral triangle (see Ref. [1]):



To what point can we complicate the task? Where is the limit of the human brain?

## Glossary

**Block** – a set of parameterized levels for preparing olympiads.

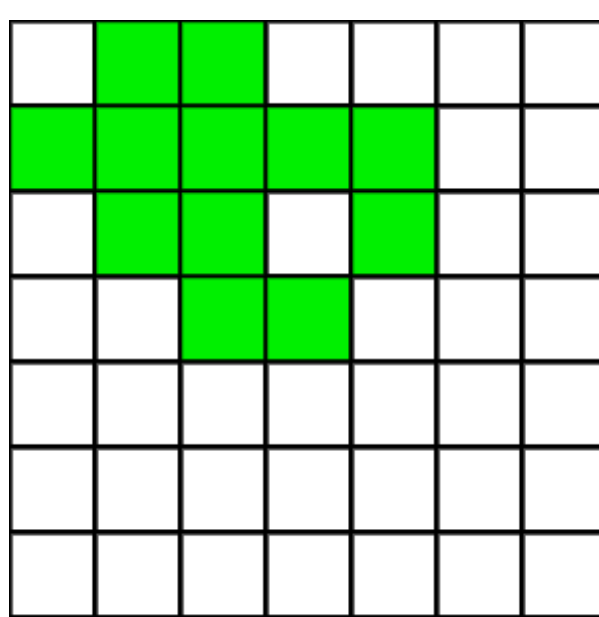
**Level** – difficulty of tasks generated by a trainer in a particular setup.

Usually trainer provides a few levels.

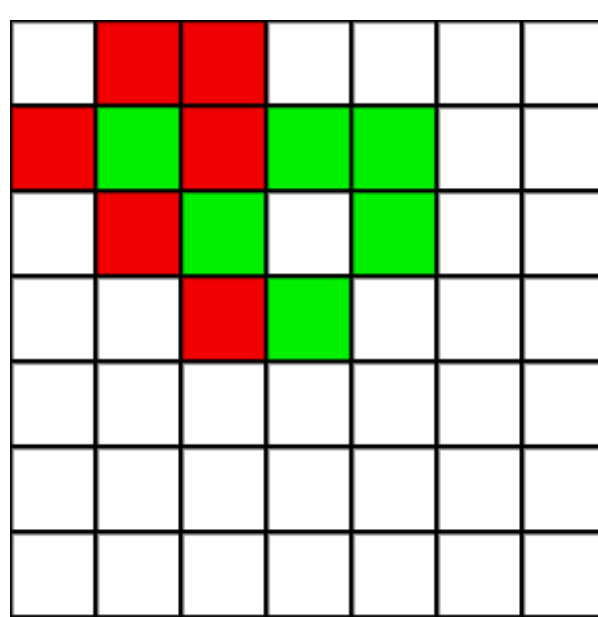
**Task** – a small and easy to understand problem.

**Trainer** – a computer program integrated into MindTrainer system that generates random tasks of the same type using given parameters.

**Olympiad** – a time-limited competition during which participants solve the tasks from different trainers.



(a) Task



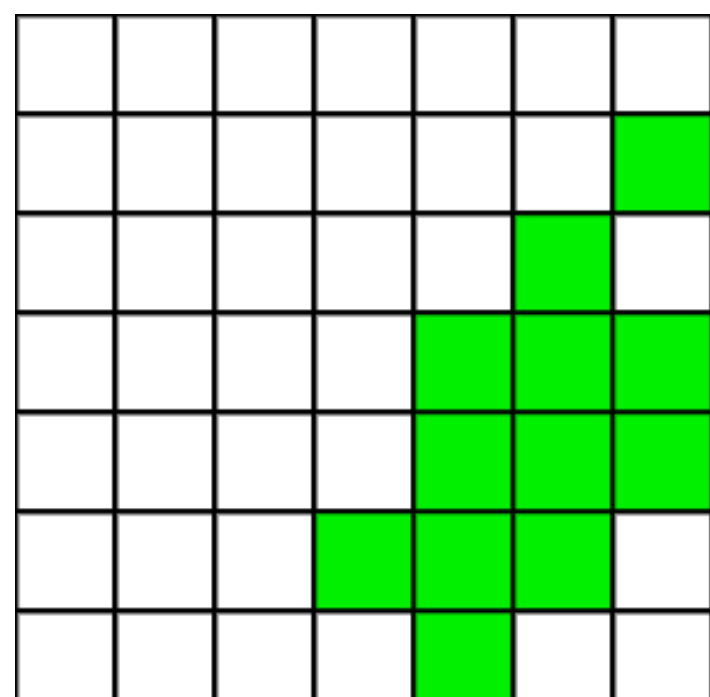
(b) Solution

Figure: Example task. Cut the green figure into 2 congruent parts

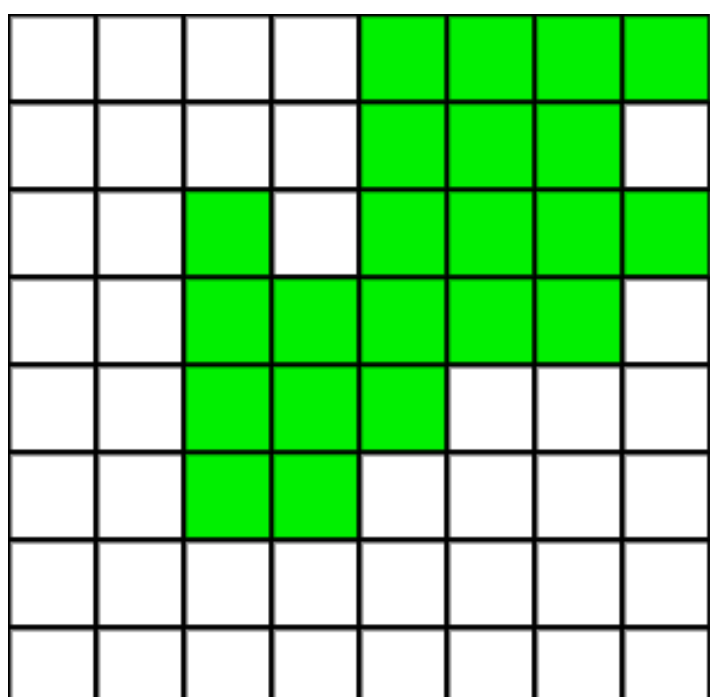
## Block-Level-Task system

The process of "mind-training" is solving of trainer tasks. Solved task earns you points (the more difficult the trainer the more points you get). The goal of each olympiad is to score the most points. Solving the same tasks can be quite boring, so we have added levels. Levels are sets of trainer parameters sorted by ascending difficulty. Each trainer has several levels (usually from 5 to 10). You start from level 0 and proceed to the next level when you correctly solve 5 (could be changed) tasks in a row.

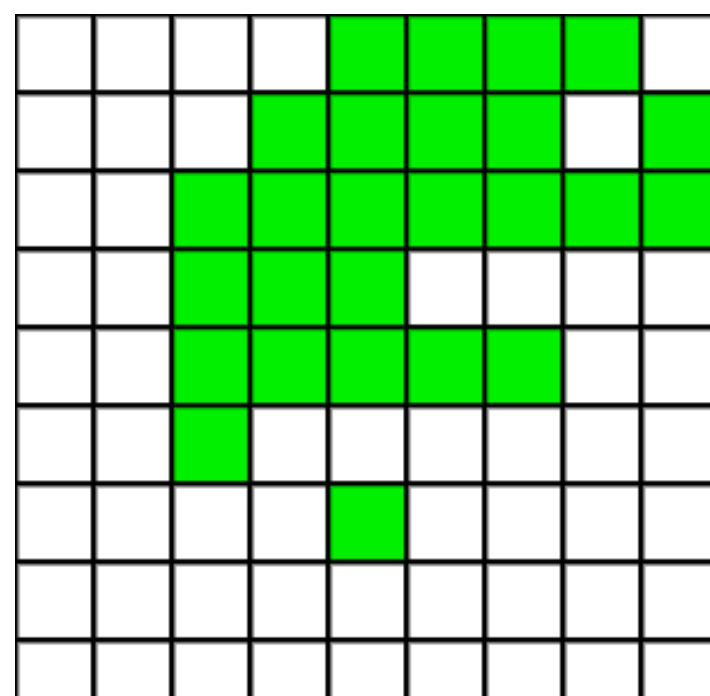
Here are examples of problems for different levels:



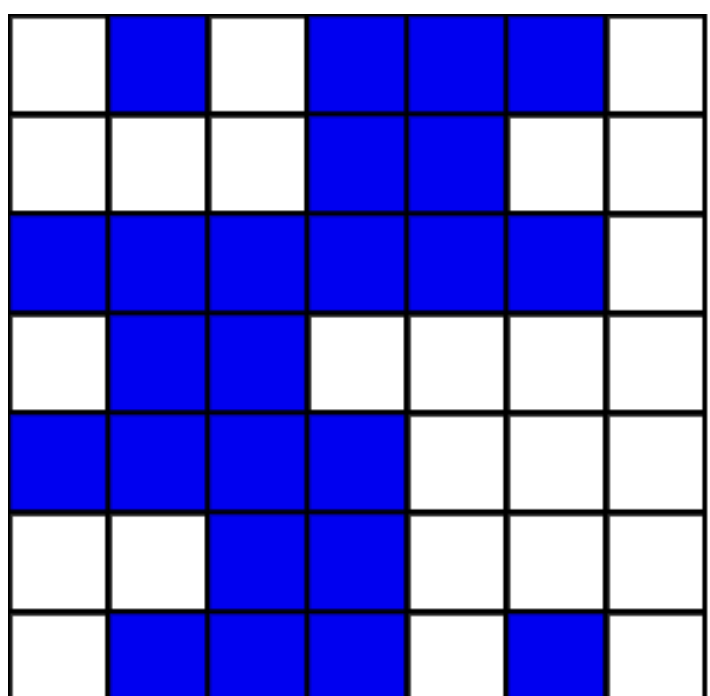
Level=0, Board=7, Parts=2



Level=1, Board=8, Parts=2



Level=2, Board=9, Parts=2



Level=3, Board=7, Parts=3

Figure: List of levels / block example (for figure cutting)

We combine levels of one trainer into a block. Using this feature, administrator of the site can create and tune a large amount of blocks and name them. After this any olympiad can be easily carried out by selecting blocks from already existing without tuning them. For example, olympiad for primary schoolchildren we can use blocks **Simple figure cutting** and **Obvious symmetry**, but for NSU students we will use **Unsolvable cutting** and **Big Hamiltonian graphs**.

## Study

To ensure diversity and quality of tasks, we researched and invented them using the following criteria:

- No additional knowledge required to solve the task
- The task is scalable, it means you can create both simple and complex tasks by changing it's parameters
- There is a fast algorithm to generate and check the task (you can create a trainer for this task)
- The task is interesting

At this moment there are 12 different trainers. Tasks are generated randomly, so the probability of repeated task tends to zero with increasing size of problem. You can check out examples of tasks of some of them on sidebar.

## Results

We designed and developed fully functional site for hosting intellectual Olympiads. The site provides 6 trainers and supports administration for preparing blocks for olympiads. The site also supports integration of new trainers that motivates study of programming languages and information systems.

Several olympiads have already been held with a large number of participants:

- the olympiad of students of the Mechanics and Mathematics Faculty of Novosibirsk State University
- two olympiads within the "Mathematical Marathon" (<http://diogen-nsu.ru/node/281>) (2017 and 2018)
- local Olympiads at math camps (<http://diogen-nsu.ru/rinrut>)

The following map shows the regions where the olympiads were conducted:



Figure: Map of MindTrainer olympiads

Analysis of achievements of participants allow us to select trainers that any age try solve and trainers that younger children find difficult to solve:

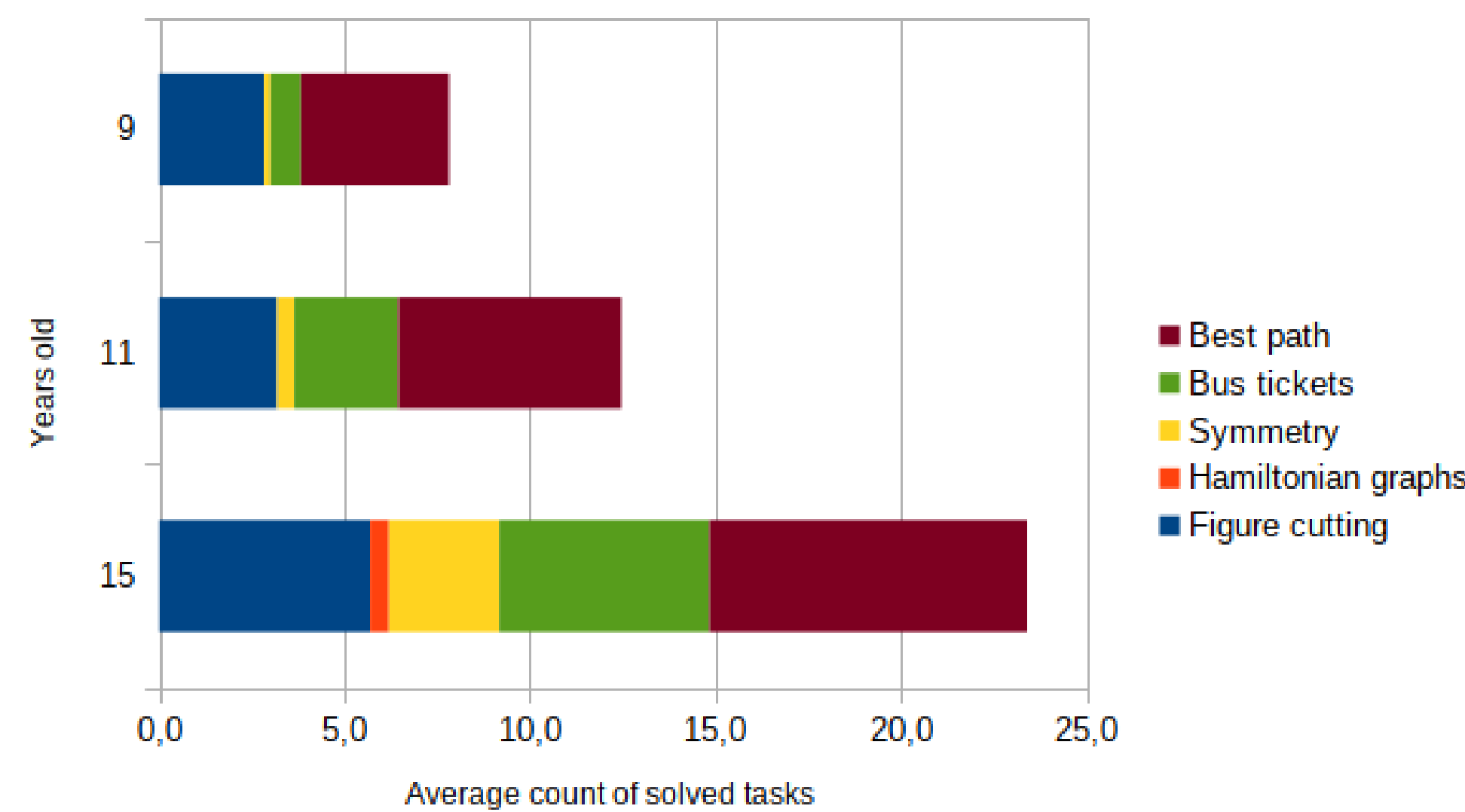


Figure: Combined results of olympiads for primary and secondary school children

## Technical part

The back-end (the server part) is implemented in Ruby on Rails. The front-end (interface, design) is written in HTML5, Embedded Ruby and SCSS using the Bootstrap framework. Interfaces of trainers are written in JavaScript using jQuery. Also, AJAX is used to accelerate loading of pages.

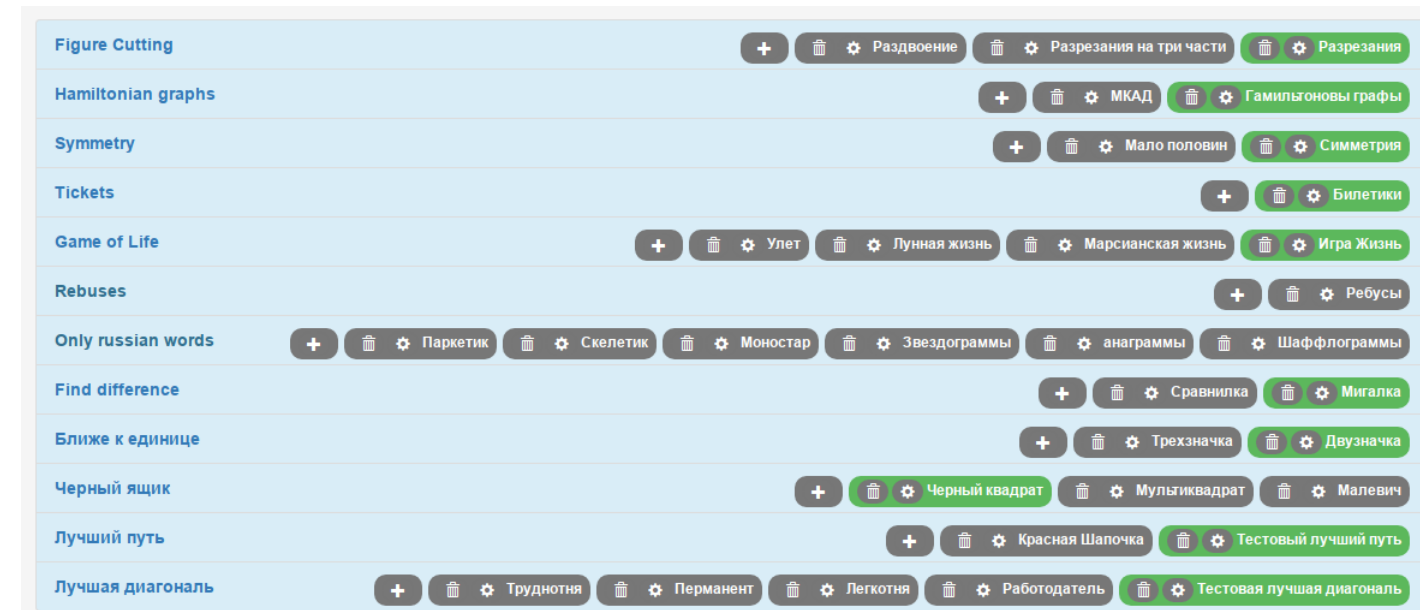


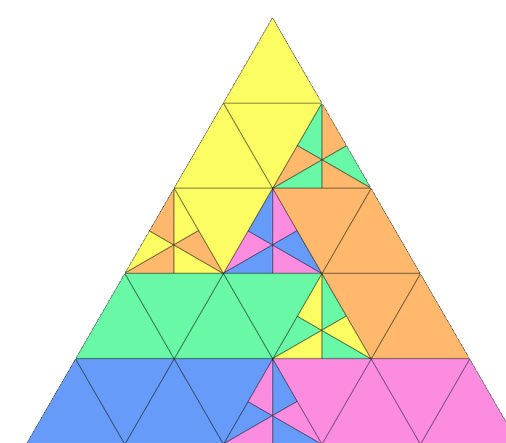
Figure: Menu of blocks

Параметр	0	1	2	3	4	5	6	7	8	9
Отступ от центра	1	2	2	2	2	2	2	2	2	2
Размер квадрата	7	8	9	7	10	8	9	7	9	11
Количество фигур	2	2	2	3	3	4	4	5	5	6
Максимальный размер фигуры	5	10	12	7	15	9	15	5	10	8

Figure: Block parameter control panel

## References

[1] 5-equal-part cut of equilateral triangle is found by Michael Patrakeev from N.N. Krasovskii Institute of Mathematics and Mechanics, <https://ru-math.livejournal.com/831851.html>



## Acknowledgements

I wish to thank various people for their contribution to this project; My friend **Alexander Krotov**, who developed the core of "Symmetry" trainer; My teacher **Anton Tarasov**, who developed the "Hamiltonian graph" trainer; My teacher **Larisa Panfilova**, who helped me to organize olympiads in primary school; Special thanks should be given to **Ph.D. Sergei Vladimirovich Avgustinovich** from Sobolev Institute of Mathematics, Novosibirsk, Russia, my scientific adviser for his professional guidance, valuable support and constructive recommendations on this project.

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