Expand Your mind by solving difficult mathematical puzzles in Scratch

Jelena Hadži-Purić, Nevenka Spalević

Faculty of Mathematics, University of Belgrade, Serbia

Mathematical grammar school

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Kids in primary school like Scratch

What about students or successful contestants in International Olympiad?

Our students

- Faculty of Mathematics, University of Belgrade

- Pupils from special National Mathematical grammar school (MG school) for gifted children aged 12-19.

- It is lucky ocassion to have top 100 pupils and 500 students, but the tasks in mathematics and programming that we should prepare for the students and gifted high-school pupils should be very similar to the previous tasks on (junior, senior, student) International Olympiad in maths and programming.

Challenges and limitations of learning environment for gifted students and contestants

- They are curious, prefer experiments and simulations before and after lectures that deal with important theoretical concepts in maths, physics, informatics and astronomy

- It is challenge to push them to further explore "heavy" algorithms and computational maths, because it is much easier to become junior Web developer and earn some money

- At start, the solution is animated lectures and visual learning environment such Scratch

The impression of our gifted students about Scratch

- 1. syntax relaxation (Not having to worry about semicolons and right parentheses freed them up to really tinker.)

- 2. self-directed learning in classroom and creative thinking through Game Design and Multimedia.

- 3. it is possible to further explore some test cases for competition tasks in maths, physics and programming

- 4. they like to be developers and to assist to the the teacher in Scratch simulation

Motivating gifted pupil and students to practice problems from mathematical and programming contest

Student *(20th Century)*

- Appreciation for theory?
- Tolerance for abstraction and test case evaluation?
- Algebra?
- Geometry?
- Modeling?
- Creative/innovative?
- Computer skills, interest?

Y Generation *(21st Century:* less motivated, less uniform, more cynical*)*

Interpret, implement, publish, sell

=>

- Demystify modeling, lift the algebraic curtain
- Visualization/animation
- Powerful what-if (more likely to apply what they have learned)

EE = Extraordinary Errors before we introduce Scratch for our gifted students and pupils (2001-2009)

- **Assume students are interested, motivated for theoretical concepts and abstraction**

- **Assume chalk-and-talk will work**

- **Assume good quant background**

- **Assume students can generalize, specialize, analyze, synthesize, apply**

- **We are CS geeks, they are normal peeps who sometimes don't see the forest for the trees**

- **Assume you know about teaching**

The main advantages of using Scratch in our courses

- Our learning material introduce the concepts of algebra, optimization and time complexity relatively early in the form of brain games (realized in Scratch).

- The competition results and our evaluation research show that this early experience with mathematical foundation of computer science facilitates the successful learning of other important concepts like efficiency algorithm design.

National and International Competition in maths and informatics

- It is important to carefully analize specific tasks that deals with problem situation

- Our kids learn to model problem statement as Scratch project in order to carefully analize all possible test cases (very important for competition in programming because only test cases are scored)

- Here are some examples!

ChildrenAndCanibals.sb

- **maths IV grade, math with CS VII grade:** There are three boys and three native - cannibals on the banks of the river. Everyone wanted to go to the other bank, but they had a boat which can hold two people. If it is known that if in one place is more cannibals than boys, than they will eat boys. Could everyone safely cross to the other side? Find the way!

FarmerBoatWolfCabbage.sb

- maths IV grade, math with CS VIII grade): There are farmer with a boat, wolf, goat and cabbage on the bank of the river. The farmer needs to cross to the other bank and to transfer wolf, goat and cabbage. But the boat can fit only farmer and a cabbage or farmer and a goat or farmer and a wolf. The farmer does not leave the wolf and the goat on the same bank because the wolf will eat a goat or does not leave goat and cabbage because the goat will eat the cabbage. Find the way for safe transport to the other side for the wolf and the goat and the cabbage.

RiverProblem.sb

- More compact and structured coding

MouseOwk.sb

- There are Serbian, Nigerian and Chinese each with his wife on the bank of river. Everyone wanted to go to the other side, but they had a boat which can hold two people. Just the men agreed to do so when it turned out that none of the women did not want to be left alone (without her husband) or with other people's husbands, or to pass to the other side of the boat with other people's husband. How did these people go to the other side?

# Grading contest (modeling) tasks done in Scratch

- In past: very hard to grade some unstructured solution like: boat goat wolf :-< wolf cabbage

- It is much comfortable to evaluate algorithm (code) written in Scratch for each sprite/script

Preprocessing some tasks in Scratch

- **A little bit different task**: One of the 2011 coins is defective. Is it possible to have two measurements at scales without weights and determine whether the coin is lighter or heavier than other?

- **Simple Scratch model project**: One of the three coins is defective, but it is not known whether the faulty coin is lighter or heavier than the other. How to use scales without weights to found defective coin?

Smart kids need smart professors -master thesis: TestVisualPerception.exe

- Applications for classifying people with disability in visual perception (in basic: SVM and machine-learning tasks).

- The test and training set were get by Scratch application that contains several different visual and audio stimuli contrasting colors, objects that disappear and appear at the click of button, adequate sound (voice and music), environmental determinants.
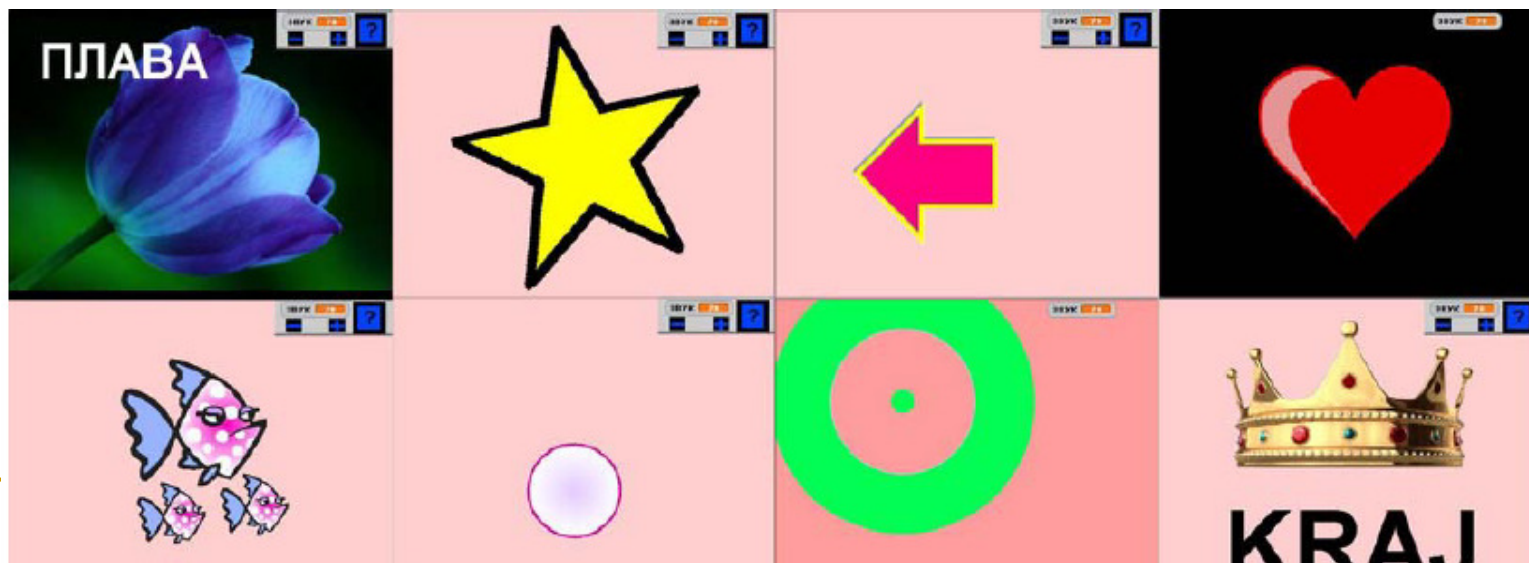
Learning mode (ACM/IEEE-CS Curricula)

- Obligatory courses in MG school and Faculty of mathematics that include Scratch:

- Introduction to programming

- Discrete mathematics

- Mathematical equation in physics

- Algorithm design and complexity

- Operating systems, networking and communication

Learning topics and aims

- Algebra and algorithms (binary search through the game GUESS THE NUMBER, the greatest common divisor, primality test, generating perfect numbers, polynomial evaluation,...)

- Computational networking (message unicast, multicast, broadcast, simulate local area networks with hubs and/or switch and/or router)

- Computational geometry (various computational fairy tales)

Scratch learning material chapters

- the Scratch IDE; sequential computation; coordinates and directions; spatial initialization;
- concurrency in the form of multiple sprites and concurrency in the form of multiple scripts for a sprite; interference in concurrent programs;
- unbounded, bounded and conditional loops
- communication and synchronization by sending and receiving messages; waiting;
- Storing and recalling values in variables;
- conditional execution, events (other than receiving messages); randomness;
- computation: accumulators and counters;

Scratch localization

- Department for Computer Science of MG school customized and localized Scratch instructions and user interface in Serbian language
- In Cyrillic alphabet.
- Native language localization is preferable not only for preschool kids, but even for students.
- We have explored official dictionary for Open Office and Libre Office localization created in Faculty of Mathematics, University of Belgrade
- Localization in Serbian is demanding task, because Serbian is morphologically rich language (fourteen derivaition for noun in sinular and plural form) with lot of ambiguity
- For example:

Stage=pozornica, scena

Script=program, skript

Compress=kompresuj, sabij, sažmi

Why bother with all of this puzzle activities in Scratch?

- Using Scratch in class/labs
  - Interactive/active learning and discussions
  - Real-time modeling and analysis
  - Modulate cognitive load and offers new avenues into brains
  - In general, increases student comfort with tech
- Using Scratch outside class
  - Increased access to material
  - Can claim more of students' time
  - Extend lectures, keep the fires burning
  - Continuous/distributed learning

Lectures

Labs
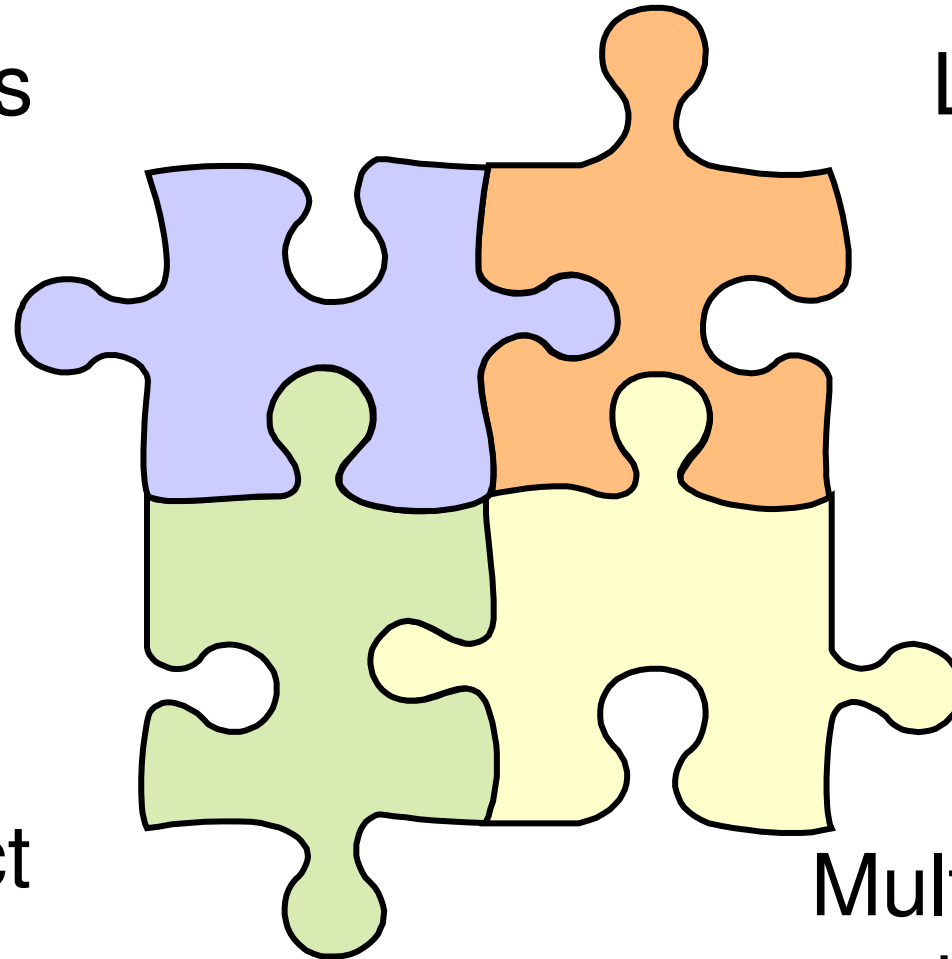
Contact

Multimedia
and Web

Some important topics for jIMO and jIOI preparation can't be covered using Scratch => Snap

- data structures (arrays, graphs,...)

- procedures and functions

- recursion

- text file input/output

- analytical geometry

Topics for some important projects

Edutainment

- Brain Games
- Popular TV quiz (Would You like to be a millionaire, Crossword puzzles,...)

Forecasting

- Predicting climate challenges (City of Belgrade)
- Forecasting Call Centre Demand

Scheduling

- Scheduling fast food delivery
- Scheduling call center for prevention of adolescent violence

Technology and resources

1. GeoGebra 4.0 for visualization of mathematical objects

2. Math JAX (modern CSS and web fonts for beautiful math in all
   browsers)

3. Scratch for developing simulation and mathematical models

4. PHP for dynamic server-side scripts

5. MySQL database for test and quizes

Conclusion: Advantage for using Scratch in education gifted students

- Scratch is great for preparing interactive teaching and self-learning materials.
- It is free, easy to download and install
- It speaks Serbian.
- It is easier to sketch some explanation for students in Scratch, than on paper

Future work

- Scratch 2.0 localization
- Cloud functionality in our learning material

Contacting us

- E-mail: hadzipuric@gmail.com
- Twitter: Jelena Hadzi-Puric

Thank You!

Gràcies