# THE ROLE OF MODELLING IN PROBLEM-SOLVING – RESULTS OF AN ONLINE COMPETITION II.

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**Abstract**. According to international surveys, Hungarian education focuses on lexical knowledge rather than its application. In our permanently changing world, the education also needs to keep pace with development. As knowledge is soon out of date, it would be important to present a significant amount of problems in education which motivate students to solve practical problem, not even drilling the theory. My previous article titled "Change of Problem-Solving Ability – Results of an Online Competition I", presents the first part of the results of a two-step research, carried out in 2008 and 2016, with student of the same age. My question was, how much the student's problem-solving ability has been developed during their secondary school years. The evaluation shows that students in these high school years did not improve significantly in solving IT problems. In this article**,** I deal with problems that come from the topic of modelling. The methodological value of modelling is twofold: on the one hand, it initiate the process of creative thinking and, on the other hand, develops heuristic problem solving.

**Keywords**: problem-solving, IT education in school, modelling, logical problems, web competition, creativity, challenge

## 1. Introduction

Information and Communication Technologies' (ICT) tools continue to grow, and lifelong learning is becoming increasingly important. The development also affects the change of knowledge, since acquired professional knowledge expires in approximately ten years. It would be important for elementary education to prepare students for real life as well, but according to international surveys (e.g. Pisa [4, 5]), while the education of the Far East and the Anglo-Saxon countries is problem based, contrarily Central and Eastern-European education prepares students for higher education, primarily through the delivery of lexical skills. [2] All of these facts warn that traditionally theory-based education that the realizable knowledge and problem-solving should have a greater role in the near future.

A possibility in realizing this purpose is to use examples from the field of modelling in the IT lessons. Modelling issues [1] are almost lacking in public education, despite the fact that it is possible to play a number of complex tasks with students, which helps them to understand abstract concepts.

Different kinds of solutions are recommended for different age groups, for example, use of application systems in elementary school, writing a program in higher education, and both types of solution**s** can be considered in the secondary school. Therefore, I searched for problems that could be suitable for public education as well.

## 2. Research: two experiments and their comparison

In two surveys of the research, I was wonder how students' problem-solving ability evolve during their high school studies. For the first time in 2008, as part of the Challenging Competition, I examined the problem-solving power of teams of 10-15 year old students, and in 2017, I repeated the study among university students representing the same age group.

I gave instructions to the problems on which the contestants were able to start. However, this was not the case for everyone. One of my first, somewhat unexpected experience was just this: in the case of relatively simple exercises, the students are able to think differently. This revelation led me to pursue to discover also their thinking methods during tackle with problems.

Two problems of the competition were presented in the previous article, so I will consider here the remaining two. The "betting" problem is a bit easier than the "beetle on the edges of the cube", but both are difficult enough to recommend as part of high school or university education. However, with the solutions I have provided, a primary school student can solve them as well.

The "betting" problem actually involved solving multiple exercises, but each could played in a few steps. One could expect that some students would play the game repeatedly, using the results they would outline an expected value and try to validate it at the end. However, such a solution was not achieved.

After presenting here Problems 2. and 3. (with their original numbers), at the review of the solutions I will follow the reverse order from didactic reasons.

## 3. The problems

**Problem 2. "Betting".** Joe wants to go to a museum with an admission price of 50 yuan, but he has only 10 yuan. He asks for a loan from Georg who likes to play, so he offers to win this money with one of the following games. Which game is worth choosing for Joe and how big is his chance to win 50 yuan? On average, how many games are played until the result is reached?

- „Double or nothing” game with one of the following rules:
    - The player always puts all his money, except when he has only 40 yuan, then he risks only 20 yuan.
    - The player always plays with all his money.
    - The pot is the minimum of the existing money and the missing amount.

- Coin toss: One of the players is betting on the HHH, the other one on the HTH combination and the winner is who first tosses their own combination. Is your combination of choice important? Why?

**Hint:** Instead of using complicated probability calculation formulas, you should consider the following:

- Look at which situation could occur during each game!
- Double or nothing: How much money Joe may have?
- Coin toss: Which are the better combinations?
- Draw an arrow between the states according to which state can be reached from a given state and write on the arrow, how likely this transition is.
- Create a table where the first line is the initial state, and the following lines indicate the possible situations and their probability after each game!

**Problem 3. "Beetle on the edges of a cube".** A beetle walks on the edges of a cube. Our goal is to reach from a corner to the opposite one. It does not know the edges, so on each corner, it can chose any of the three directions with equal chances. Once the beetle starts on an edge, it will reach the end.

- What is the probability that after 10 steps the beetle will reach the goal?
- After how many steps can we say that there is more the beetle reached the target with more than 90% chance?
- If after the beetle starts we place in its source corner a spider which eats beetles, then what are the chances of the beetle reaching the opposite vertex or being eaten by the spider?

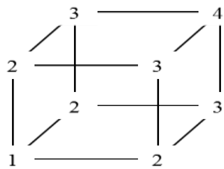
**Hint:** Instead of using complicated probability calculation formulas, it is worthwhile to use the same logic as at Problem 2. A spreadsheet program can help you count.

## 4. The solutions of the problems

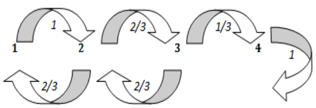
### 4.1. Beetle on the edges of the cube

Group the edges according to the distance from the starting point. There are four different states:

1. initial point,
2. points at a distance of 1 from the starting point,
3. points at a distance of 2 from the starting point,
4. points at a distance of 3 from the starting point.




A state diagram can be used to illustrate the the individual states and the probability of the beetle entering it. From point 1 you can move only to poit 2, so it will done with 1 probability. Each vertex 2 has its neighbors: 1, 3 and 3, so there is a $^2/_3$



probability to reach a point 3 and probability $^1/_3$ to the point 1. Point 3 is symmetrical to 2, and the point 4 is the node where the beetle can not go any further, so it stays with probability 1.

Based on the state diagram, a matrix can be completed, with $(i, j)$ elements indicating the probability that the beetle will move from state $i$ to state $j$, in a step. Based on the above analysis, the enclosed matrix is obtained.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 |
| 2 | $^1/_3$ | 0 | $^2/_3$ | 0 |
| 3 | 0 | $^2/_3$ | 0 | $^1/_3$ |
| 4 | 0 | 0 | 0 | 1 |

Since initially the beetle is on vertex 1, the starting state can be described by the vector (1, 0, 0, 0). The next step is obtained by running the start state on the status diagram to get the state ($^1/_3$, 0, $^2/_3$, 0). Note that this can be obtained by multiplying the start state with the matrix describing the status diagram. Continue the matrix multiplier until the value of the point 4 is almost 1, i.e. it differs with a given $\varepsilon$ from 1. So the solution is: the beetle will reach the goal state, after 10 steps with 63% probability, after 21 steps more than 90% chance.

If a spider is placed in the starting state, the vertex 1 is converted to a trap position, i.e. the element of the matrix [1,1] is set to 1. Then the stopping state will be that the probabilities at nodes 1 and 4 will differ by $\varepsilon$ from 1. So the chance that the spider will eat the beetle is 60%, and the chance that the beetle will reach the target is 40%.

### 4.2. Betting

As at the previous task, we can draw a status diagram for each game, which illustrates the movement of money, as well as it can be converted to a matrix. The starting state shows our starting position, which multiplied by the matrix, we obtain the state after one step. This is continued until the sum of the non-absorbing states are less than a given ε, but a stoppage condition can be the condition that the sum of changes in value, after a step is less than ε.

## 5. Students' solutions and evaluation of the questionnaire

### 5.1. Beetle on the edges of the cube

I intended this problem to be the hardest, and 65% of the participants accommodated, they also thought it was most effortful one. Apart from two university students, everyone agreed that this task was difficult, however 78% of the participants started it to wok out, and 22% thought they had solved the problem. (Students from the 2008 experiment were quite realistic, but in the 2017 experiment, most of the students' self-estimation was fulsome; they often thought that their partial solutions were complete.)

The two experiments yielded similar results, but there were no absolutely correct solutions, but 33% and 36% of the participants were close to a complete solution. There were two university students, who developed programs, which gave the best approximation to the correct result.

### 5.2. Betting

The solutions of this problem brought an unexpected result. The young students in the 2008 experiment performed much better than the older participants in 2016, which was contrary to my original expectation. Originally, I thought that this task could not be a problem for an IT student. Adding to these facts that 53,8% of university students found this problem difficult, and 15,4% of them considered it easy, we may conclude that the students underestimated the difficulty of this problem.

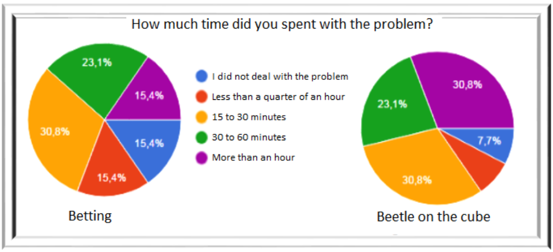
In the "double or none" game, the situations and the state transitions were generally well pictured, but a significant part of students could not properly score up the probabilities. Many have solved the basic version of the game well and realized that when we did not put all the money, we had a better chance, but they could not determine it.

In the "head or tails" game, it was a general mistake for students regarded the HHH and HTH combinations of the same chance.

## 6. Comparing the two tasks

Despite the fact that most of the participants did not have a sense of accomplishment, both tasks were popular for 52% of partcipants, which was more than I originally expected. Between the two tasks, the ratio of indifference (22%, 26%) and disapproval (26%, 22%) was chosen. The participants in general prefered the "beetle" problem to the the problem of "betting". This again does not match my original expectation or the fact that the "betting" task was found to be easier for students and had higher amount of correct answers.

It was interesting to compare the times spent on problems. Twice as many students spent more than one hour on the "beetle" problem and only half of the participants spent less than a quarter of an hour. This result serves as evidence that the "beetle at the edges of the cube" is a more imaginative problem among young people.



## 7. Summary, Future Plans

The results of the surveys show that students' problem-solving power does not show significant improvement during their high school years. It draws attention to the shortages of public education, but above all to the obsolete orientation of the educational concepts. We need to act as soon as possible in the possibility of reintegration and change of direction.

The IT subject can be suitable for dealing with real-life problems. A specific problem is often related to a particular subject, but knowledge elements of several subjects are involved.

When solving a problem, we will also develop the knowledge gained in several fields of information technology. During the task of the gathering necessary information, students gain knowledge of the internet usage. One of the tools to solve the problem can be writing a program or using an application system. Introducing a problem may be achieved through creating a presentation.

In the continuation of the research, my next attempt would be to study the knowledge transfer of students and how they build upon a part of their knowledge networks in a special area. When students have already seen a certain type of problem and are familiar with their solutions, how they would be able to apply their knowledge independently to solve problems, requiring similar modelling.

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