CHANGE OF THE PROBLEM-SOLVING ABILITY – RESULTS OF AN ONLINE COMPETITION I.

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Abstract. In our constantly changing world knowledge is soon out of date. According to international surveys, Hungarian education places preference on lexical knowledge rather than its application. In this article, I search for the answer to the question on how student's problem-solving ability develops in today's Hungarian high school education. The research performed on this subject consisted of two parts. At first in 2008, as a part of an online competition, I studied how eleven years old students solve thought-provoking problems of which they can get the knack with smart thinking and creativity rather than skills and lexical knowledge. As a continuation of the work, in 2017, I repeated just the same problem-solving task with university students of similar age, so I could compare the results of the students of the same age-grade before and after high school studies. Based on the evaluation, it can be said that students' problem-solving skills did not increase significantly during their secondary school years. Presenting some problems of the competition, I would like to give an idea of how thoughtful problem solving could be introduced into education. In this article, one half of the exercises, the logical ones are presented, and I will discuss the rest of the problems, that need modelling, in a next article.

Keywords: problem-solving, IT education in schools, logical problems, web competition, challenge, creativity

1. Introduction

According to international surveys, the education of Far East and Anglo-Saxon countries is problem solving based, while Central and Eastern European education prepares students for higher education. [2] According to the TIMSS international survey, fourth and eighth grade Hungarian students achieved average results (for example, in mathematics, the Finns and the Poles are about the same level), but on the PISA survey they are only in the last third. [4, 5] The background to the significant difference may be that PISA examines the ability of adapting knowledge to the practice, while TIMSS calls for lexical knowledge. It seems that in our schools, the curricula are focusing on lexical knowledge rather than its application. These facts warn teachers and people of educational policy that the time has come for updating the conception of traditional elementary education. Definite steps should be

made soon, toward exploring working knowledge for teaching and enhancing problem-solving activities, either individually or in a group. [1]

2. Research: two experiments and comparisons

In a two-step research, I was wonder how students develop their problem-solving power their high school studies.

The research consisted of two parts. The first survey was made in 2008 as part of the Challenge competition. Challenge was a three-round online competency development game that could be used by teams of 10-15 year olds. The essence of the game was fast and efficient navigation on the internet. Instead of the basic knowledge, the integration of existing knowledge elements, creativity, logical understanding, adaptive and problem-solving accomplishment has come to the foreground. It was important to work in a team for cooperative work. The ultimate goal of the Challenge internet game was to give students a playful and enjoyable space for fantasy, using creative imagination and self-cultivation.

The second part of the survey was carried out in the 2016/2017 academic year, with the involvement of willing students of similar age, from the department of informatics. (The two experiments did not include any common students.) In the first competition participated 15 teams and in the second survey 20 students, so the result cannot be generalized, only indicative. Therefore, both interested and good-performing students in the two experiments do not represent their own age, but give it a kind of upper limit. [3]

In the first competition, the participants received five problems. One of them, the 5^{th} exercise became so easy for now that I omitted it for the second time. The first experiment was a playful and frisky competition with more motivated and team-mate-supporting students who eventually managed to solve all the problems. In the second survey, students worked on their own, and on average only two or three problems were dealt with.

For the following two unconventional problems (with original numbers 1 and 4) there was insufficient to use the basic knowledge; on the contrary, creative thinking was needed to their solution. This was a great advantage to work in teams, having the opportunity to share ideas and complete the solution together. That is why – as a suggestion – it would be important if group work also would play an important part in public education.

3. Logical puzzle

Problem 1. Five friends were on holiday during the Olympic games and they wanted to watch the finals of their favorite sport on the TV. Find out from the

information given hereinafter, which sport (wrestling, kayak-canoe, handball, shooting or water polo) was which friend's (Adam, Billy, Charlie, Daniel and Eric) favorite and on which day (Monday, Tuesday, Wednesday, Thursday or Friday) and at what time (16.30, 17.00, 17.50, 18.00, 18.40) was the final broadcasted on TV!

- Eric, who like Daniel, is not fond of water polo, watched the TV on Monday.
- Adam, who likes kayak-canoe did not watch TV on Wednesday and not at 17.00.
- Handball was held at 17.50, but not on Monday, and it was not Billy who watched it.
- Daniel, who does not like shooting, watched the TV at 16.30.
- The last final game started on Friday and it was not the kayak-canoe.
- The person who watched the TV on Tuesday did it not at 18.00 and it was not the person whose favorite sport is handball.

Hint: Try to create a table!

3.1. Solution

In the following table, we denote the connected events by X and we use 0 for the non-connected events. Create the logical consequences of the above facts. The initial and the completed tables are the following ones:

		Sport					Date					Day				
		wrestling	kayak-canoe	handball	shooting	water polo	16.30	17.00	17.50	18.00	18.40	Monday	Tuesday	Wednesday	Thursday	Friday
Name	Adam		X					0						0		
	Billy			0					0							
	Charlie															
	Daniel				0	0	X									
	Eric					0						X				
Day	Monday			0												
	Tuesday			0						0						
	Wednesday															
	Thursday															
	Friday		0								X					
Date	16.30															
	17.00															
	17.50			X												
	18.00															
	18.40															

		Sport					Date					Day				
		wrestling	kayak-canoe	handball	shooting	water polo	16.30	17.00	17.50	18.00	18.40	Monday	Tuesday	Wednesday	Thursday	Friday
Name	Adam	0	X	0	0	0	0	0	0	X	0	0	0	0	X	0
	Billy	0	0	0	0	X	0	0	0	0	X	0	0	0	0	X
	Charlie	0	0	X	0	0	0	0	X	0	0	0	0	X	0	0
	Daniel	X	0	0	0	0	X	0	0	0	0	0	X	0	0	0
	Eric	0	0	0	X	0	0	X	0	0	0	X	0	0	0	0
Day	Monday	0	0	0	X	0	0	X	0	0	0					
	Tuesday	X	0	0	0	0	X	0	0	0	0					
	Wednesday	0	0	X	0	0	0	0	X	0	0					
	Thursday	0	X	0	0	0	0	0	0	X	0					
	Friday	0	0	0	0	X	0	0	0	0	X					
Date	16.30	X	0	0	0	0										
	17.00	0	0	0	X	0										
	17.50	0	0	X	0	0										
	18.00	0	X	0	0	0										
	18.40	0	0	0	0	X										

3.2. Students' solutions and evaluation of the questionnaire

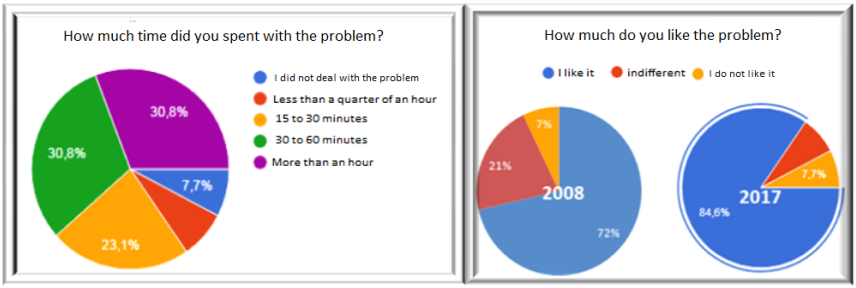
This problem seemed both interesting and complex at the same time, to give a feeling of success, but it was easy enough for many to solve it, to set up motivation through the whole competition.

It can be said, that both experiments produced similar results. Participants generally chose the tabular or the enumerative solution method. Some of the students only commented on it and there were students who only provided the final solution, but the most interesting solution was a computer program. However, both of the two experiments resulted with one incorrect solution.

I was also curious about how much time the participant dealt with the solution of this problem. The attached diagram also shows that the completion time on average is 30-60 minutes, but one third of participants spent more than an hour on the solution.

Based on the answers to the question, this problem was interesting enough to spend a longer time with it. The 78.3% of the participants in the two experiments liked the problem and 70% of them told that they had met a similar logic puzzle before.

Surprisingly, there was a student who considered this problem to be the most difficult one. This also confirms proposal to increase the emphasis of logical problems in education, which is further considered to be a well-founded idea based on the participants' positive interest in this logical problem.



4. Twenty Questions

Problem 4. Joe and George play twenty questions in a way that George thinks of a special sport - from the Olympic sports chosen by Joe - then Joe puts five questions in a row to which George answers at once and Joe will find out the sport. You also should think of such a twenty questions game! Make a table that

- includes the sports (may be winter or summer Olympic sports);
- contains the questions;
- includes the answers to the questions (be careful not to have two sports for which the answers are the same)!

Try to create twenty questions with as many sports as possible!

4.1. Students' solutions and evaluation of the questionnaire

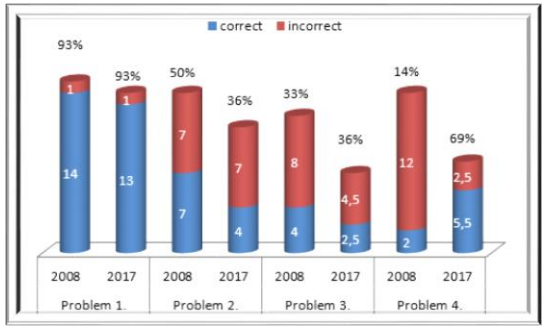
This was also an easier problem, with the aim of focusing on acquiring and organizing knowledge in the frame of logical thinking.

I expected everyone to gather at least 10 sports, but I counted on average 15 sports. By contrast, many of the participants in the 2008 competition unfortunately misunderstood the problem and only two correct solutions were created with 12 and 25 sports. During the 2017 experiment, there were several correct solutions with 5, 7 and twice 13 Olympic sports. The reasons for the incorrect solutions were:

- putting different questions for each sport;
- there were no decisive questions;
- there were no given specific names for sports;
- there was only one, undefined question for each sport.

According to the feedback from the participants, this problem was the most uninteresting, only 46% of the students liked it, and 42% of them were indifferent. This may also explain the multiple contradictions that participants did not consider the problem difficult, however only 66% stated that he or she had solved it, and as a matter of fact a lower percentage of students had correct solutions.

5. Evaluation of the two experiments



Comparison of the two experiments reveals that participants in the 2008 survey did not perform significantly worse. There were problems with similar results. Problem 1 was solved by 93% of the participants in both surveys. In the case of Problem 3 (not included here) only 3% of students achieved higher results in 2017, compared to the 2008 trial. Problem 2 (also not specified here) was 14% better completed by the 2008 participants (younger students), than the 2017 group. Problem 4 was not fully understood by the 2008 group, and the participants in the 2017 survey performed 55% better. However, the best solution for Problem 4 came from the younger group.

In the 2017 experiment, some of the students thought they had correctly completed certain problem, however, they had given only partial solution for that problem. The same over-confidence was also apparent in [3], where the students who thought themselves to be highly competent, performed the worst.

In both experiments, the problems were novel for the participants, apart from logical puzzle.

6. Summary and future plans

These results show that students' problem-solving ability has not improved significantly during their secondary school years. This partly draws attention to replace the shortages of public education and partly to the need for reconsidering the goals and aims in public education.

An intended direction of my future research will be the study of the problem-solving facility of higher-grade university students, as some studies show that a significant leap can be found in the problem-solving power of students during the second and third year. Another direction can be to provide additional ideas for training problem solving ability by suggestion of new types of problems.

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