MEET – OPEN PROBLEMS: Two cases from practice

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Thirty "brains" - winners of school Olympiads - were combat-ready. They had just been given problems to solve, and the countdown had begun… Twenty minutes later I came up to one apparently preoccupied chappie, 'What's the matter?'

'Well, the problem appears to move onward, but I never understand where to insert this figure.'

I read the problem condition[1].

In 1785, the French balloonist Charles threw down a stone from a balloon rising at a speed of 1 m/s. How long will the stone fly to the earth if it was thrown down from the height of 300 m. Air resistance may be neglected.

The problem was simple, of the "heating" type, but the boy was puzzled by the figure '1785'. He knew from experience that problem conditions only gave necessary information and no excess detail...

There are thirty teachers in front of me. I offer them a "tricky" problem.

How much will the water level rise in a bath if a brick gets into it?

The immediate reaction was perplexity. 'What kind of bath is meant? What kind of brick?' I say, 'Take approximate standard sizes!' After that, practically all of them solved the problem promptly and without hesitation – the volume of displaced water will be equal to the brick volume.

My question was 'Have you thought twice before answering?'

And immediately a sober thought arrived from the floor.

"And suppose the bath is full of water! Then the water level will not change because part of water will just slop over.'

'Very good! Is that all?'

'No, no! – the audience was reanimated, 'there may be very little water, the problem condition does not specify the amount of water… If water does not cover the entire brick, it will be displaced only by the immersed portion of the brick. The displaced volume may be calculated if the water depth is known…'

'Thus,' I summarized, 'in this problem, you should supplement the condition with the lacking elements yourself. Actually, you have made a small investigation. As a result, the problem condition is split into three parts:

1. when the water level is lower than the brick;
2. when water covers the brick, but the bath is not full;
3. when the bath is full.

This is an **open** problem. You have coped with it. Now, let us learn to conduct an in-depth investigation into the open problem.

The problem condition reads, '… a brick gets into it.' Let us think how the problem could change depending on the manner in which the brick gets into the bath.

The audience was enthusiastic.

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[1] The problem statement is cited from memory.

'The brick can fall into the water with a high speed splashing the water by the impact!'
'Or even punch a hole!'
'What is the brick like? What kinds of bricks are there? Are there bricks lighter than water? What do they say about this in the encyclopedia?'
'And suppose the brick was hot! The problem condition doesn't say anything about it! Then we could easily calculate how much water would evaporate and how the water level would change…'

'That'll do,' I say. 'You've apparently begun to enjoy the process. Now, using our experience, we can compose several quite traditional closed problems about 'the bath and the brick' and to solve them in a traditional manner until a numerical result is obtained…'

PROBLEMS AROUND US

We solve the problems we were taught to solve. School teaches us to solve closed problems. The closed problem formula comprises a clear statement + an approved solving method + the only correct answer. Any sidestep, to the right or to the left of the approved solving method (hence, thinking method!) lowers the mark.
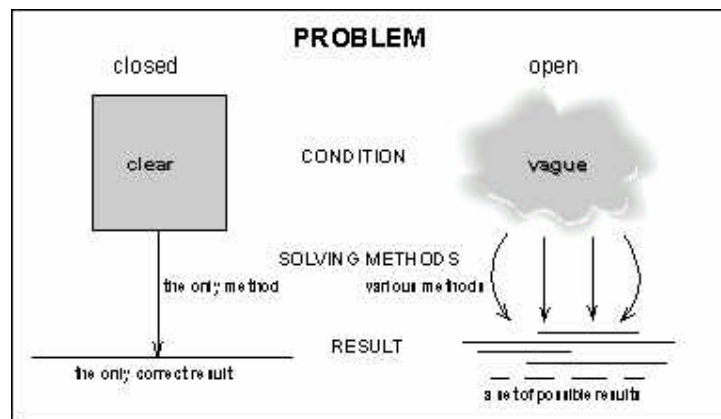
Psychologists distinguish thinking into two types – *convergent* (closed, non-creative) and *divergent* (open, creative). The type of personality with the dominating convergent thinking is referred to as an 'intellectual' and that with the dominating divergent thinking as a 'creative'. The intellectual is ready to solve very complicated problems but only those which have been already formulated by somebody else and have known solution methods – just the closed problems I mentioned. The creative is capable of seeing and formulating problems himself, tends to transcend the boundaries of the formulated problem conditions… No doubt, each person has both intellectual and creative abilities, though in different degrees. As a person grows up, creative thinking 'decays'. Most high-school children and students are conformal, afraid of independence, do not gravitate to original thinking but prefer to be spoon-fed by information arranged in an orderly pigeonholes. The problem statement uncertainty and a variety of possible solution methods of a creative problem frighten them. This is quite logical, because of conventional teaching methods.

It is impossible to teach flying to a bird confined in a cage. It is impossible to grow a 'creative muscle' without tasting the freedom of 'open' problems admitting various approaches to solving, different degrees of immersion in the problem's inward nature, and different versions of results…

There are no fields of human activities devoid of open problems. You can find then in technology, science, as well as in everyday life, art or human relations…

Do you wish any examples?

Cat and starlings[2] (everyday life)

As soon as birdlings started cheeping in the birdhouse on the tree, the cat appeared. He was walking around and licking his lips, smelling a prey. The boy who built the birdhouse wanted to help the birds. He devised a method to block out and away the access to the birdhouse for cats. What did he do?

Swordfish power[3] (science)

How do fish and dolphins contrive to move in dense water with speeds more characteristic of a flight in air? According to some sources, a swordfish, for example, achieves a speed of 130 km/hr. To gather such a speed in water, the swordfish must develop a power of a car engine – on the order of 100 h.p. Living beings draw energy from oxidation processes. But fish are cold-blooded, their temperature is little higher than the temperature of water in which, by the way, a very small amount of oxygen is dissolved. Such a power is unattainable for them! It may be suggested that fish are somehow capable of considerably reducing water resistance. But how? This question is still unanswered.

How to win a name for oneself?[4] (human relations)

The Papuans of Boldai tribe choose a name for a newborn according to an ancient, very cruel rite. Parents look out a clever, laborious and highly respectable man from the neighboring village, kill him so as to take his name for their baby. Their neighbors do not like this rite, but what can they do? And yet, the Head of the Boldai tribe managed to defeat this horrible, barbaric prejudice of the tribal society. How did he manage to do alone what many generations of tribesmen were unable to do?

Perspective in ballet[5] (art sphere)

When staging a ballet, a stage director decided to achieve a visual effect of reducing figures of hunters as they disappear in the wood, just as it occurs in real life. But the stage is not large and the dances are not visually reduced in height. What is do be done?

Closed problems are only found at school. In real life, there is almost no place left for them. Program-controlled machine tools, computers and other useful machines successfully cope with closed problems.

- How to establish neutrality with rough children in the yard?

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[2] The boy wound a sheet iron around the tree. The problem is taken from the book by G.Ivanov *Creation Formulae or How to Learn to Invent*. Moscow: Prosveschenie, 1994. – p. 97.

[3] From the manuscript of I.Andrzeevskaya and A.Guin *Biology in Open Problems*

[4] The problem is presented by the colleague from Vladivostok Anatoly Limarenko. Here is the solution. Chibu, the Head of the Boldai village began bringing from the city video films, postcards, statuettes, and portraits of actors, sportsmen, and film stars. He managed to convince his tribesmen that the names of those people were just as good as other names. Now, to give the name of a favorite cowboy or film star to their first-birth, all they need is just to buy a postcard and to spear it. The people breathed freely – inventive Chibu defeated the horrible rite.

[5] The author of the problem is Valentina Berezina from Chelyabinsk. Here is the answer. 'I formed the dancers into six groups according to their height. The tallest hunters passed along the nearest path with respect to the audience. On the next path, they were replaced by a second group of dancers, still shorter hunters passed along the third path and the procession was competed by the group of the shortest hunters crossing a bridge. They were presented by children. The same gradation was observed in music which was gradually becoming quieter and quieter until fully died away… The colors of the dancers' costumes were also fading away.' G.G.Noverr. Letters about a Dance, 1965. – p. 106.

-   How to make the acquaintance of a boy (girl)?
-   Where to continue study after school?
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Similar youth problems may be considered as open problems. Those teenagers who do not cope with them corrupt their own characters and make miserable their own life and the life of the folk around them.

School teaches solving closed problems. Life issues the challenge to solve open problems. The efforts of teachers and motivation of school children vanish in the gap between the school reality and the demands presented by life.

"Ass-headed" talents

An incorrigible pass-mark pupil and notorious troublemaker Kolya struck me as a fairly quick guy. After another conflict with the teacher, we had a confidential talk with him.

'Why should I respect her,' Kolya says. 'She pounded this book for five years at her university and she has a key book and I don't have keys. Give me her key book and I will also be clever…'

Later I found out that this stereotype is quite characteristic of such children. Who knows how many capable children do not adapt themselves to school and diddle away their time there. I mean clever and active children who are full of life but sometimes look as backward "ass-heads" in class. Frequently cited references to the seeming obstitancy of Einstein-pupil, Mendeleev-pupil, or Brodsky-pupil as well as of some other great thinkers are of the same series. Their free and open minds just did not fit into the school designed for mass production.

The future genius was in the first form when the teacher publicly called him a "brainless ass-head" and the indignant mother took her soon from school. Thus, the formal education of Thomas Edison only lasted several months and all the rest he attained under the guidance of his mother. Fortunately, the boy read much and, contrary to the children of the same age, used to make toys by himself instead of cadging them from his parents. By the age of ten, he opened the list of his inventions by making a miniature timber mill and a toy railway.

Sasha was a pupil of my new 8A class[6]. Sasha seemed to be slow. During a test exercise, I gave him some questions and a textbook - just find answers and copy them! He did not cope with the task – he did not manage to find the required material! Some time later I learned that Sasha was accounted to be a specialist in motor bicycles and could disassemble and repair an engine. This doesn't seem like stupidity, does it? I tried to go into the question, to get to the heart of the matter, and make friends with the boy. So it is! The same uncared-for child, full absence of motivation. He 'does time' at school while the real life is outside school[7]. Why?

I think that permanent 'mortification' of the free thinking of creative children, attempts to fob off stereotyped thinking upon them, impels some children 'to take on the defensive'. You may ask what is do be done? These stereotypes, or, in other words, thinking, solving or even figuration rules are very useful, aren't they? Certainly. Beyond doubt. Just as the fact that a house needs a roof. But if the roof presses on the head and does not allow you to stand up, be sure that you will have either a spinal curvature or a broken roof.

One of the test problems set by the teacher was how to measure the height of a skyscraper by using a barometer only. In the evening, while checking the papers, the teacher marked that many pupils understood correctly how to use a barometer for determining the height – to measure

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[6] The described event took place in 1981.

[7] We managed to gradually amend this situation. Sasha finished the 8th form with quite a satisfactory mark.

the atmospheric pressure on the ground floor and on the last floor. However, one of the pupils wrote that because he knew that the mercury level in the glass capillary of the barometer makes thirty inches, he would measure the length of the shades from the barometer and the building and then would calculate the height of the building using trigonometry.

Next day, the teacher called the pupil and asked him, 'I would be wrong saying that your solution is incorrect, but it is really so. I meant an aneroid barometer, not a mercury one. Now that you know what kind of barometer I meant, how would you answer this question?'

The boy gave the teacher an answer bang off, 'I would got up on to the roof, throw the barometer down and measure the time of it flight to the earth. Then I would get an answer from the free fall acceleration.'

'You are right and you are not right again,' the teacher said. 'Try again, suppose you don't have a watch.'

'Then I would find the custodian of this building and tell him, 'If you tell me the height of this building, I will give you this barometer[8].'

The boy is a typical creative. Imagine that he finds himself in a school where they punish by bad marks for any original solution. Or give encouragement only to stereotyped solutions, which, in effect, is the same. What would happen to the boy in several years? Would he love school or would he be reluctant to study? The last question is rhetorical. We know what would happen. We see the answer in the today's school. It is impossible to teach flying to a bird confined in a cage…

Factors of success

What determines the successfulness[9] of a man in life? This was my first question at the seminar for law teachers in Moscow. We wrote down about 30 most important factors of successfulness and started discussion, recollecting various examples from history and everyday life and creating a hierarchy of factors of successfulness…

Money? Starting capital? Yes. But there are lots of examples when a beautiful idea and the ability to solve problems created huge capitals from minimum means.

Wozniak sold his gratuity calculator XII-65 for 500 dollars. Jobs, wishing to keep secret the fact of having 5000 dollars on a bank account for the participation in the game "Break the Wall" conducted Atari, sold his Volkswagen truck, thereby providing half the initial capital of the enterprise[10]. This is how the starting capital of the company 'Apple' – one of the leading monsters of the computer market – appeared.

The multimillionaire ship owner Onassis, financial leviathan Rothschild, oil magnate Rockefeller, creator of the first mass car Ford – all of them were contrivers, inventors, open problem solvers.

By the way, history knows a lot of examples of losing all savings due to one unfortunate step…

And what about school and university education? All of us know that first students do not always become first in life. Even in science, 'school successfullness', the volume of knowledge received at school are not the dominant factors of success.

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[8] The case is described in the book by Nirenberg,G.I. *Creative Thinking Art.* Mn.: Puppuri, 1996, p. 218.
[9] We have defined the notion of "successfulness" as follows. The person is successful if h? himself thinks he is successful and the folk about him agree with it. In other words, if he has achieved by himself something important for himself and for other people.
[10] The fact is taken from the book by Mingo, G. *Secrets of Success of Great Companies (52 stories from business and trade).* SPb: Peter Press, 1995.

A.Hall is one of those who have not got any special education and come to astronomy not just from another field of knowledge, but from the sphere far removed from science. He is a carpenter. Having studied mathematics under the guidance of his wife – maths master – he soon showed great successes and was invited to one of American observatories. Hall immortalized his name by discovering Mars satellites Phobos and Deimos[11].

At the age of 42, being quite a known American painter, but absolutely ignorant in the theory of electricity, Morse was captivated by the idea of 'information transmission by wire'. He invented telegraph and was one of the founders and the first president of the National Academy in New York[12].

Then what about health? – Certainly. But there are many exceptions here, too.

We can judge the level of environment from which he had to emerge by his father's letter. The address was 'To Professor of Esperanto Vassily Yeroshenko, Peking University, China' which was written with all possible spelling mistakes[13]. That was the level from which Vassily Yeroshenko, a blind peasant boy emerged to high education in a series of fields of knowledge and became Professor of Esperanto not only at Peking University but also at Tokyo University.

The results of Yeroshenko's activities are huge. Three books of novellas and stories in Japanese. Today, the writer Ero-san (this is the name under which Yeroshenko is known in Japan) is the classic of the Japanese literature, his tales are among other literary works constituting the compulsory course of the Japanese junior school. The writer and playwright Airosyanke is well-known in China. He was the first in the world to make records of Burmese and Siamese folklore. One can still find newspapers with his articles in English, German and Esperanto. Blind Turkmenian children are still taught by means of his alphabet – he has developed Braille for Turkoman (the one for Chukotka remained unfinished).

He developed a unique foreign language training method, a method for teaching blind people to move by themselves. Yeroshenko himself walked without a stick even in unfamiliar cities. One could only notice his blindness when coming near him[14].

Stephen W. Hawking is a well-renowned cosmologist and Acting Professor of Cambridge University. He is 56. He has a rare disease called Lou Gehrig disease and cannot move any more. Only two fingers on his hand are active and he uses them to type words on a computer display and communicates with the audience through an electronic voice synthesizer[15].

It looks as if there is only one quality which is absolutely and undeniably required for achieving considerable success – the ability to solve problems. Sure enough, open problems – professional, household, psychological – are meant.

A creative person sees open problems where other people will only see a failure or the divine scourge. Look at the world with your eyes open wide and the world will appear an endless open problem in which a physicist, a biologist, and a teacher – each of them will see his own subproblems. It is necessary to learn to see problems as the blind Yeroshenko did it. Here is, by the way, an example of a pedagogical problem solved by him in an amazingly beautiful manner.

In search for students (he did it himself, too) for his Turkmenian school Yeroshenko came across a blind orphan named Durdy. It was a wonder that the baby survived at all. All he knew

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[11] The fact is taken from the book by Yu.G.Gulevich *Metallurgists Invent*. M: Metallurgia, 1990.

[12] The fact is taken from the book by Berezina, V.G., I.L. Vikentiev, and S.Yu. Modestov *Creative Person Childhood: Meeting a Miracle. Mentors. Worthy Goal.* SPb: Bukovsky Publishing House, 1995.

[13] It is clear from the spelling that the letter was written by a semiliterate peasant from a remote Russian province.

[14] After the article by Ingrida Murashkovska and July Murashkovskiy "*I Set Fire to Your Heart…*" You may find this article on the site of the Universal Solver Lab at www.trizway.com

[15] The fact is taken from the journal "Znanie – Sila", no.7, 1978.

was hunger and constant kicks for begging. He was entirely convinced that all people were beasts and that he was unwanted in that world. Yeroshenko brought him to his school, gave him to eat and to drink. In such a situation, pedagogical norms recommend that the child's confidence be won gradually, during several years. But Yeroshenko could not delay an instant. He took Durdy to the mountains (by the way, Yeroshenko was a good amateur alpinist). They reached together the top of one of the mountains and Yeroshenko asked the boy to shout his name. 'I am Durdy', the boy cried out. And the mountains echoed his name twice. 'Now you see,' said Vassily Yakovlevich, 'even here, in the mountains, everyone knows you and loves you…'

During many years after the death of Yeroshenko, Durdy Pitkulayev was the director of that same school in Turkmenia[16].

What do Greek by birth, international businessmen Aristotle Onassis and the blind boy from a Russian village Vassily Yeroshenko have in common? Both of them were successful though under different conditions and at different times. One of them could have remained a night dispatcher at an American port and the other one could have spent all his life in a poor Russian village. But they were able to see problems, they were not afraid of problems and they solved them as freely as they breathed.

What is the conclusion? Solve depthward…

Survival problems

All simple problems – if such have ever existed at all - have been solved so far. We are constrained to solve complex and very complex problems. It sounds optimistic because the humankind will have to grow wiser in order to survive.

Absolutely new problems of different nature are arising. For example, in the years immediately ahead, there will appear people with computers built in their bodies. And afterwards, this fate awaits all of us. How will it happen? In a very simple way. First, high tech medical sensors will appear. For instance, a special device will warn a sick man against a danger of an attack. The man himself does not fill the approaching disaster and is exposed to a great danger. The device will warn him as well as his relatives and doctor. High medical risk people such as those with cardiac problems will be additionally protected. The device may serve not only as a sensor. It will be able to apply first aid - to make an injection or electrostimulation. Does it sound realistic? Surely! So, the first symbiosis of a man and a computer has appeared.

The farther the more. And if there is already a computer inside, why not to add some harmless functions to it – let it also serve as a telephone and contain a secret electronic code for opening a safe (a garage, a flat…). The farther the more…
And if you think that all these 'redundancies' are too expensive, I would like to refresh your memory.

At the beginning of the fifties, a semiconductor transistor cost about fifty dollars. Ten years later, its price was about two dollars. Today, a transistor incorporated in a microcircuit costs 1/100 000 of a cent.

Is it possible or not to stop the process of combining a man and a machine? If it is possible, then is it necessary? One of my acquaintances, a religious man, is quite serious calling a mobile phone a 'devilish gimmick'. However, he uses it – such is life. Here is an open ethical problem – how should this process be treated? By the way, what is the attitude of churchmen,

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[16] From the article by Ingrida Murashkovska and Yuly Murashkovskiy "*I Set Fire to Your Heart…*"

antiglobalists, communists and other '…ists' to this process? What shocks will this process entail for a society? What should be done to prevent a too painful and bloody effect? Thus, we have passed from the ethic problem to a social one. And who is ready to solve these problems?

The research conducted by Wellcome Trust proved that English school leavers are not ready to deal with complicated ethical problems generated by modern science.

Nothing is being done to teach schoolchildren to give thought, quietly and impartially, to such problems as fetal cloning, tests on animals and genetically modified products. The opinion of schoolchildren is not based on scientific facts.

Teachers are worried by the low interest in important events and news as a whole. They also mark that schoolchildren have very stable opinions about such problems as rights of animals and cloning which are formed on very sparse facts[17].

I tell you, technical problems that are comparatively familiar to us are not becoming simpler, neither. Ecological problems on the Earth will arise continuously or until the humankind leaves this planet. And it is interesting that the more powerful the man, the more costly are his mistakes.

Mistakes are sinking ships, oil spills, ravaged forests, collisions of nations… Correcting these errors involves huge expenses. As time goes on, optimal solving of open problems becomes critical for the survival of the humankind.

Post Script added after the article was submitted:

Life itself is a big open problem people have to solve every day. We would like people to be happy. To be happy, they must be efficient problem solvers. This is just why we work on the development of the theory of inventive problem solving (TRIZ) and teach solving creative problems to adult specialists and children of different ages.

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[17] The source of information: http://www.compulenta.ru/news/2001/7/16/15805/.