METHODOLOGY

# Theory and Practice of Training in Talented and Innovative Thinking in Schools

Part 2.

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# Content

# Chapter V.
# Methods with Wide Practical Application

**Juliy Murashkovskiy**

## Methods of Activation of Creative Thinking

All models and approaches to talented thinking can be divided into two groups:

- purely theoretical discussions of psychologists of the problems of talented thinking. As a rule, these discussions do not lead to presentation of sample cases of practical application of their findings;
- concrete measures of activation of creative thinking (heuristic methods). There are many examples of application of these measures, and they are usually based on updating or improving of the already known measures and approaches.

The main stock of measures for activating talented thinking is, in fact, a rather large number of variations of the already existing core methods:

1. **Brainstorming** – a method worked out by Alex Osborn**.** Osborn classified people into two types – generators, or those who easily develop new ideas, and experts, who evaluate these ideas. The groups work independently, which allows the generators to propose different and sometimes most incredible ideas without fear of criticism because these ideas are to be evaluated later. [2]
2. **Method of focal objects** developed by E. Kuntze. The main idea of this method is transferring the features of accidentally chosen objects on the improved objects, which leads to emergence of interesting ideas. [4]
3. **Morphological analysis** method elaborated by the astrophysicist and researcher F. Zwicky**.** In its simplest variant, the main idea of this method lies in designing of a two- dimensional matrix where each axis represents variations of the essential quality of the system. The boxes of such matrix contain different ideas. With the help of morphological analysis, F. Zwicky

foresaw existence of the neutron starts and suggested several innovative ideas in the field of aviation. [3]

4. **Method of control questions.** The inventor responds to the questions from the list and analyses the task in the context of these questions. Lists of such control questions have been prepared by many authors, including A. Osborn, T. Aloart, D. Poya etc. [5] [6]

5. **Synectics** method elaborated by W. Gordon is upgraded brainstorming where four types of analogy are applied: direct analogy (any analogy, e.g. to a natural phenomenon); personal analogy (empathy) – an attempt to work with the task identifying oneself with its object; symbolical analogy – identifying the task or object or joining the idea of it with an idea carrying opposite features, like: fountain – flowing immobility; glass – invisible wall etc.; fantasizing – interpreting of the task in terms of tales, myhths and legends. [1]

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[6] Изобретатель и рационализатор N'5, 1970 г.

# Theory of Inventive Problem Solving (TRIZ)

Today the single algorithm-based approach towards development of talented thinking is **TRIZ – Theory of Inventive Problem Solving** (Rus. *ТРИЗ – теория решения изобретательских задач*) elaborated by G. S. Altschuller.

The theoretical background of this theory is based on the thesis proposed by G. S. Altschuller: all systems, including those established in the cultural framework, develop according to immanent laws that are independent of the human will. Talented thinking and its development are in complete agreement with these laws.

A distinctive feature of the approach to research into talented thinking applied by Altschuller is categorization of inventions into five levels. Levels 5 to 3 indicate essential changes of the existing systems. Levels 2 and 1 indicate insignificant or routine changes. Talented thinking can be applied only to solution of tasks that can be assigned to the highest levels, therefore the TRIZ model and the related follow-up researches are focused only on the inventions and discoveries of the highest levels.

Altschuller succeeded in identifying the basic laws of development of the technical systems (Rus. *законы развития технических систем* - *ЗРТС*) [1] that appeared to be applicable also to other systems. [9] Nowadays, the laws of analogy have been identified in the systems of arts [9] and the systems of scientific phenomena. [6] [7] [8]

The followers of Altschuller identified analogy laws in different systems, both artificial and natural ones.

The system of the laws of development worked out by Altschuller is based on the ARIZ algorithm of solution of tasks demanding inventiveness. It is a sequence of intellectual operations leading to the best solutions of highly complex technical tasks. TRIZ methodology also includes the system of standards used for solution of invention-related tasks – a detailed sequence of stages of development of technical systems in the framework of the basic laws of development of these systems. This system permits not only to solve important technical problems quickly and qualitatively, but also to foresee possible future inventions.

Information foundation is a very important part of the TRIZ methodology. This foundation comprises a set of detailed indicators of the physical, chemical, geometrical and biological effects that are used in the invention processes, as well as typical schemes of conflicts in the systems and typical methods of solution of contradictions. These indicators are supplied with multiple examples. [2]

In order to provide psychological support for talented thinking, Altschuller elaborated a course of teaching creative imagination (Rus. *развитие творческого воображения* - *РТВ*). It is a complex system of the laws of imagination as well as methods and exercises for its development. [4]

Taking into account the fact that the owner of the brain performing talented thinking is a human being living in a definite social context, Altschuller elaborated the basics of the theory of development of creative personality (Rus. *теория развития Творческой Личности – ТРТЛ*). The background of this theory is a system of qualities of a creative personality (Rus. *система качеств Творческой Личности* - *КТЛ*) and the life strategy of a creative personality (Rus. *Жизненная стратегия Творческой Личности* - *ЖСТЛ*). The theory of development of a creative personality is based on the study of several thousand biographies of talented personalities who were famous in the field of the highest level inventions and discoveries. [3]

Different software solutions based on the TRIZ methodology and rendering support in making inventions and discoveries in the dialogue regime have been developed and elaborated in many countries. [5]

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# Chapter VI.
# Some Elements of the Theory of Talented Thinking

**Juliy Murashkovskiy**

## Introduction

This is the first aid to the Theory of Talented Thinking (TTT).

Much has been written on the subject. However, more than two centuries of studies carried out by different psychologists have brought no applicable results. One has to find the courage to admit: it means that these researchers went the wrong way!

The first person to do this was a scientist, engineer and writer Genrikh Saulovich Altschuller (1926-1998). He created the Theory of Inventive Problem Solving (TRIZ). [11] Altschuller concluded that systems develop by their own inner laws and do not depend on man's will. During more than half a century of research he discovered a considerable part of these laws, studied the finest details of their operation and developed an algorithm for solving complicated technical problems. He was also the first to have the courage to admit that talent and geniality are not inborn gifts. One can and should learn to be talented! He made his first practical steps in that direction.

The next step towards practical teaching of talented thinking was the Theory of Talented Thinking (TTT). Some parts of the theory are discussed in this work. [61]

The basic idea of TTT: **Talent is an ability to create new concepts that differ considerably from their prototypes and open new possibilities for the mankind.**

### How Do We Measure Novelty?

What does it mean '…new concepts that differ considerably from their prototypes'? How do we distinguish 'considerable differences' from inconsiderable ones?

Within TTT, a scale of levels of inventive thinking proposed by Altschuller was developed into a five-level scale of changes that take place in the process of working out new concepts. [12] Hereby is a concise description of the scale:

> **Level 5, synthesis.** Creation of a new direction of thinking, new conceptualization of nature, society, new types or genres in art, new types of hardware. There is no definite prototype here. A prototype is a whole system of the preceding conceptualisations of things and ideas.

**Example 1:** For a long time transport was bound to dry land and water modes, but in 1647 Tito Livio Burattini made the first flying model with immovable wings. In 1848, John Stringfellow launched a monoplane with a steam engine. The model flew unaided for about 10 metres. These devices changed the concept of transport; they enriched engineering with a new resource for motion - the air. Thus the aviation era began. [35]

**Example 2:** While watching the night sky, ancient Babylonians noticed that all the stars moved simultaneously and in one direction as if they were circling around the Earth. It reminded them of a wheel because its rim circled around the axis as a whole system around its centre. The circle became Babylon's symbol of the Universe. Gradually, people came to believe that the celestial sphere circled around the Earth, and that stars were attached to this sphere. This model changed their conception of the world. The world became comprehensible, organised and not chaotic. The science of astronomy commenced. [19]

**Example 3:** Humanists of the Renaissance were convinced that recovering the achievements of antiquity could improve human lives. They started studying antique science and art. The task was very difficult as Early Christians had destroyed almost all the testimonies of the 'pagan' antiquity. Books were washed off their ancient parchments, temples and sculptures were ruined, scientists were exterminated ruthlessly. Very few remains of the antique science and art were discovered by humanists; yet, their conceptualisation of antiquity was fantastic! For example, Jacopo Peri, a musician, attempted to reconstruct the ancient theatre but misinterpreted the recovered records and concluded that actors in the antique plays sang. Together with poet Ottavio Rinuccini, he 'brought back to life' the ancient theatricals. In the musical play they wrote together in 1594 the characters were not talking but singing to the accompaniment of the harpsichord. This was the first opera – a new art form that changed the general concept of the theatre. [85]

> **Level 4, unfolding.** The essence of the new conceptualisation remains the same but its basic elements are substituted and they become increasingly correlated with observations, experiments, and interact as an integral system. Novel theories and technological directions appear; modern means of artistic expression come to life. The prototype for unfolding the general concept is the result of changes at level five.

**Example 4:** Ancient Greeks adopted the celestial sphere from Babylonians; however, they noticed that not all the stars were moving in uniformity. Some of them diverged from the common route and seemed to wander in the sky. They were called 'vagabonds', or planets. In order to incorporate these observations into the celestial sphere theory Anaximander (*Ἀναξίμανδρος*) and Anaximenes (*Ἀναξιμένης*), as well as other ancient Greek philosophers, offered and idea that besides a common sphere of stars there existed a separate sphere for each planet, the Sun and the Moon. The general concept of the Universe circling around the Earth remained unaffected but the basic principles of the celestial motion changed. [14]

**Example 5:** The wings of Stringfellow's monoplane were flat and horizontal. Some constructors, including brothers Wilbur Wright and Orville Wright, designed drooping wings that were drop-shaped in section. It allowed them to use the aerodynamic effects and significantly increased the carrying capacity of the wings. At first the airplanes developed by the Wright brothers flew hundreds of metres, than several kilometres. [1]

**Example 6:** A young composer *Claudio Monteverdi* was present at the second performance of Peri's opera. Monteverdi immediately realized that Peri, who was an amateur, failed to use many musical techniques which were known hitherto; he wrote his own opera with an entire orchestra, expressive arias, duets, polyphonic and monadic styles. Staging and musical performance of this art form became more interesting. [85]

> **Level 3, adaptation, major adjustments.** Certain details are changed; they are adjusted to the new system of conceptualisation and combined with observations. Due to numerous details, the general picture becomes versatile,

interrelated and logical. Individual theories, novel components and parts of technical equipment are developed; new precise means of artistic expression emerge. The prototypes are prior to concrete conceptualisations, details and means of expression.

**Example 7:** Some peculiarities of planetary movement failed to fit into particular schemes. At times planets moved in the opposite direction but then again continued their progressive motion. This made ancient Greek astronomers Apollonius of Perga (*Ἀπολλώνιος ὁ Περγαῖος*) and Hipparchus (*Ἵππαρχος*) suppose that the planets had additional orbits which they called epicycles and which were independent; the planets, in their theory, were attached to the epicycles and not to the sphere. The retardation in motion of planets was explained by different circulation speeds of the spheres and epicycles. It did not alter the very idea of rotation of the Universe or individual spheres but the concept of epicycles adjusted their ideas to observations. [36]

**Example 8:** The wings of the Wright brothers' airplanes were solid and immovable. The machine was operated by a pilot who changed his position and moved the centre of gravity. Alexander Bell patented the so-called ailerons – movable parts of wings designated to control the flight level and direction. The principle of flight and the carrying capacity remained the same but ailerons facilitated manipulation of the machines. [75]

**Example 9:** Operas by Christoph von Gluck, Wolfgang Mozart, Giuseppe Verdi, Giacomo Puccini and many other composers introduced novel means of expression, diverse melodies and orchestration methods. [37]

**Level 2, idiographic adaptation, small-scale adjustments.** Insignificant alterations of particular parts and surface aspects of means of expression are made, some specific concepts are introduced. The concepts as such are not changed, they are only further elaborated.

**Example 10:** The epicycles could not explain all the peculiarities of planetary motion, so it was necessary to introduce the second and third epicycles and recognize eccentric motion (the axes of epicycles do not fully correspond to the spheres), etc. [5]

**Example 11**: In construction of metal airplanes rivets took place of nut bolts. It improved streamlining, simplified assembling but had no effect on the principles of airplane operation or function of its parts whatsoever.

**Example 12:** The technique of opera singing became more elaborated, the number of instruments in the orchestra grew, more complex decorations were created… But nothing affected the basic principles of this art form. [37]

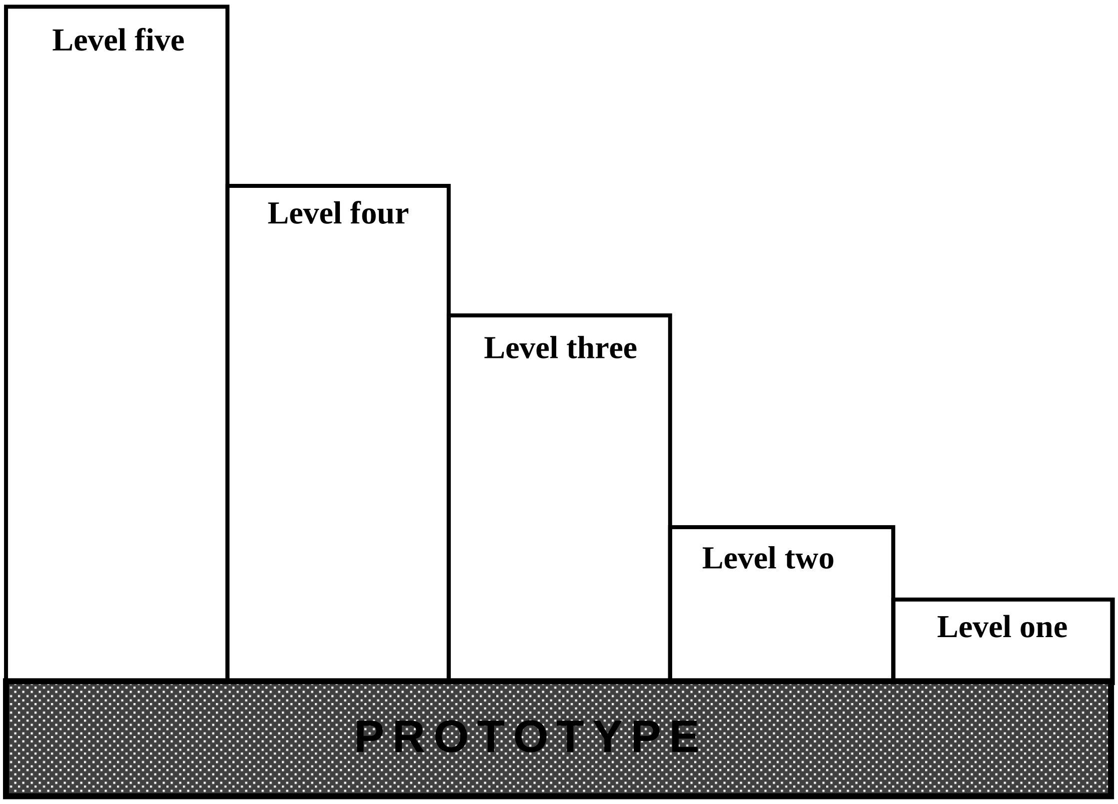
> **Level 1, regress, microscopic changes.** Common knowledge is conformed again and again; the slightest insignificant details of concepts are elaborated. Operation of technical equipment is facilitated; it becomes more convenient and economical. As far as art is concerned, embellishment, attention to the tiniest details of means of expression grows.

**Example 13:** Diameters and arrangement of epicycles, distances between spheres are calculated, the well-known orbit equations are brought to perfection. [5]

**Example 14:** Manufacturing accuracy of the surface parts of airplanes is improved. Some companies stop painting airplanes because their surfaces are smooth enough. This reduces painting expenses and the overall weight of the aircraft, which consequently lowers fuel consumption. [30]

**Example 15:** Operas are not composed anymore but delivered by ‘a conveyor belt’. As a result of the growing popularity of this form of music, opera writing resembles manufacturing of goods. All operas are very much alike. R. Wagner called them ‘unbelievably pitiful opera products’. [85]

Diagram of the scale of levels:




'Innovation' is a trendy word nowadays. In general, aspiration for the new is beautiful; yet, having examined hundreds and thousands of the so-called innovations one might come to a conclusion that 80 % of them do not rise higher than levels 1-2. There is nothing new in these 'innovations', just tiny refinements to the long- known ideas and facts.

Talented thinking is necessary to work on higher (3-5) levels. Implementation of insignificant changes on levels 1-2 requires no talent. Professional knowledge and skills are sufficient here.

But why exactly are changes on lower levels often considered to be part of talented thinking? The explanation is simple. Changes are not looked at through the prism of development but are evaluated from the point of view of their consumption and selling capacity. It is obvious that the bigger the change and the more unusual it is, the lower is its selling capacity.

**Example 16:** Georges Bizet's *Carmen* was the first opera that depicted lives of common people in contrast to heroes or ancient Gods, and because of that it seemed to be extremely controversial. Naturally, the first performance of *Carmen* was not received well. On the contrary, another composer, Stefano Gobatti, who wrote his primitive standard operas approximately at the same time, achieved a distinctive record - he was encored 69 times. [85]

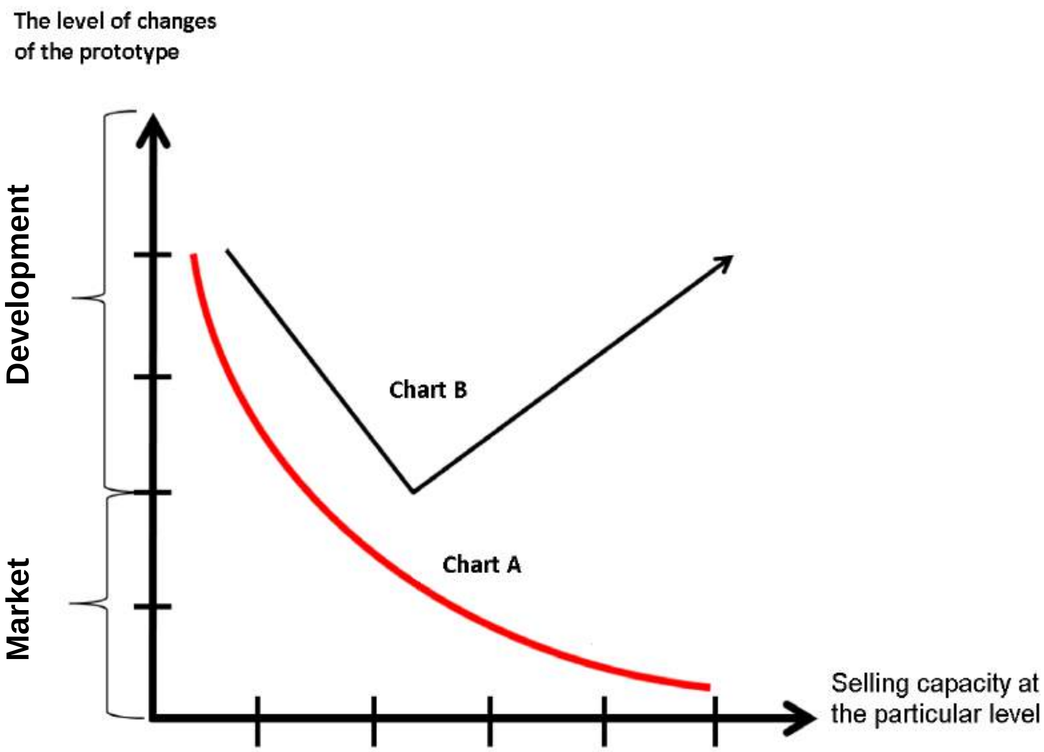



**Chart A** shows connection between development and selling capacity on each particular level. The lower the level of changes, the higher its selling capacity is. [62] That is why one of the top ten inventions of the 20$^{th}$ century was a vacuum flask and not Dewar flask. Moreover, Reinhold Burger, the inventor who patented a vacuum flask, swore that he had only slightly adjusted James Dewar's invention to kitchen needs.

Development of concepts starts at level 3 and proceeds to level 5 (**Chart B**). Further conceptualisation substitutes for the previous one at level 5. The first and the second levels do not develop concepts but they raise the selling capacity of the results.

This chart presents another peculiarity. A common claim that "small changes bring about big changes" is nothing but a comforting lie. We may introduce many 'small changes' but they will not turn a cart into a car! We may decorate a wooden house but it will not turn into Versailles!

## Procedures of Talented Thinking

In order to determine the patterns of talented thinking in the history of science, art, technology and some other spheres of human activity a selection was made of a number of inventions and discoveries corresponding to the higher levels (3-5). These days, their number is around several dozen thousand.

These discoveries and inventions were analysed using the following scheme: **was** (prior conceptualisation) – **has become** (new conceptualisation) – **method of conversion** (the method of changing the prior conceptualisation into a new one). If the repeated use of a particular method of conversion always gives a high level result, the method may be attributed to talented thinking.

It turned out to be that there are many separate methods but they can be easily grouped into several complexes. Nineteen complexes are known today, and they are called *methods of talented thinking*.

The abilities are not equal. They form a specific system. The first fourteen of them are basic; they are concrete procedures of talented thinking. The remaining five are supplementary; they facilitate acquisition and application of the basic ones.

**Basic abilities:**

1. The ability to see systemic character of objects and phenomena (systemic thinking).
2. The ability to see and formulate function of the system and to build “ideal systems”.
3. The ability to dissolve contradicitions.
4. The ability to build a generic model.
5. The ability to allocate a minimal model of the considered object or phenomenon. The ability to see the hierarchic and temporal boundaries of the qualities of objects.
6. The ability to disassociate a particular fact with a well-known model.
7. The ability to overcome the hyper model and change it.
8. The ability to depart from the super system of conceptualisations.

9. The ability to generate the absolute model of a phenomenon and afterwards reject it.
10. The ability to switch from considering one object to considering groups and varieties of objects.
11. The ability to manipulate a number of parameters at the same time. The ability to switch from one-parameter system to multi-parameter systems.
12. The ability of unlimited increasing and diminishing any parameters of objects and phenomena.
13. The ability to unfold conceptualisations of time. The ability to see processes versus only events or conditions.
14. The ability to depart from considering ontogeny to considering phylogeny.

**Supplementary abilities:**

15. The ability to control associative imagination. The ability to structure and develop analogies.
16. The ability to invent terminology.
17. The ability to process huge amounts of information.
18. The ability to see the drawbacks of the generated model.
19. The courage of thinking.

This aid will be devoted to detailed analysis of five procedures:

- The ability to see systemic character of objects and phenomena (systemic thinking).
- The ability to see and formulate function of the system and to build „ideal systems”.
- The ability to dissolve discrepancies.
- The ability to invent terminology.
- The ability to process huge amounts of information.

The corresponding chapters not only give a detailed explanation of the essence of each procedure but also provide 155 examples from various spheres of human activity, different times and nations. Moreover, each part contains tasks with controlling questions.

## Harmful Consequences of 'Correct Answers'

The notion of answer has to be discussed separately. The main drawback of modern, unimaginative pedagogy is imposing '**correct answers**' on students, while apparently 'the correct answer' is a temporary phenomenon which can often be obsolete. Students should not be taught to repeat 'the correct answer' but to seek and find an answer suitable in the given situation. They should also be aware of the fact that this answer may not be adequate in another situation. Consequently, every task has 'a controlling question'. It is an answer given in a real life situation and based on the level of knowledge and judgement attached to the particular time and particular place.

For instance, Claudius Ptolemy's (*Κλαύδιος Πτολεμαῖος*) geocentric system (where the static Earth was the centre of all celestial bodies that moved around it on circular orbits) succeeded in describing motion of celestial bodies known at that time. Still, his model was extremely complicated. While trying to simplify it, Nicolaus Copernicus (*Mikołaj Kopernik*) put the Sun in the centre of the system and showed the Earth and other bodies as moving around it in the same perfectly spherical orbits. It might seem that the problem was solved; however, the precision of the new system was much lower than that of Ptolemy's system. Calculations failed to match Copernicus` observations.

More than a hundred years later Johannes Kepler discovered that the reasons for incongruity were the circular orbits. He substituted the elliptical orbits for the circular ones, and his calculations totally coincided with his observations. The question is why Copernicus, who was an excellent astronomer and knew that his system failed to match the results of actual observations, stuck to spherical orbits? The fact is that he strongly believed in the religious conception that had already been popular with ancient Greeks: God created a harmonious world. At that time a circle was considered to be the most harmonious shape. So, Copernicus could not approve of any other shape for the orbits; they just had to be circular. He believed that over time the system would be further developed to match his observations.

If this situation is viewed as a task, then spherical orbits of celestial bodies circling the Sun is a **controlling** answer and not ‘the correct’ one. It was the answer obtained by Copernicus at that particular time and got its shape in accordance with his actual beliefs.

Our students are in a different situation; they live at different time and have different views and prejudices. Our goal is to make them understand that there are no ‘correct answers’! There are only answers that are adequate for a particular task. After some time new conditions, observations and views will appear to make the answer inadequate; this will force them to look for another one, often a surprising or unusual answer. Students will have to do it themselves!

Consider a fragment from memories of Ernest Rutherford, a great physicist and the founder of an entire school of physics. It clearly demonstrates that there can be many adequate answers, and a true scientist and discoverer will not declare the chosen answer ‘correct’ but will acknowledge that there may be many answers. A true scientist will manage to resist the temptation of dogmatising one of these answers.

‘Some time ago, I received a call from a colleague who asked if I would be the referee at grading a certain examination question. It seemed that he was about to give a student a zero for his answer to a question in physics, while the student claimed he deserved a perfect score and would have got it if the system were not set up against him. The instructor and the student agreed to submit this to an impartial arbiter, and I was selected.

I went to my colleague's office and read the examination question, which was, *"Show how it is possible to determine the height of a tall building with the aid of a barometer."*

The student's answer was, *"Take the barometer to the top of the building, attach a long rope to it, lower the barometer to the street, and then bring it up, measuring the length of the rope. The length of the rope is the height of the building."*

Now, this is a very interesting answer, but should the student get credit for it? I pointed out that the student really had a strong case for full credit, since he had answered the question completely and correctly. On the other hand, if full credit were given, it could well contribute to a high grade for the student in his physics course.

A high grade is supposed to certify that the student knows some physics, but the answer to the question did not confirm this. With this in mind, I suggested that the student have another try at answering the question. I was not surprised that my colleague agreed to this, but I was surprised that the student did.

Acting in terms of the agreement, I gave the student six minutes to answer the question, with the warning that the answer should show some knowledge of physics. At the end of five minutes, he had not written anything. I asked if he wished to give up, since I had another class to take care of, but he said no, he was not giving up. He had many answers to this problem; he was just thinking of the best one. I excused myself for interrupting him, and asked him to please go on. In the next minute, he dashed off his answer, which was:

*"Take the barometer to the top of the building and lean over the edge of the roof. Drop the barometer, timing its fall with a stopwatch. Then, using the formula S= 1/2 at^2, calculate the height of the building."*

At this point, I asked my colleague if he would give up. He conceded and I gave the student almost full credit. In leaving my colleague's office, I recalled that the student had said he had other answers to the problem, so I asked him what they were.

*"Oh, yes,"* said the student. *"There are many ways of getting the height of a tall building with the aid of a barometer. For example, you could take the barometer out on a sunny day and measure the height of the barometer, the length of its shadow, and the length of the shadow of the building, and by use of simple proportion determine the height of the building."*

*"Fine,"* I said. *"And the others?"*

*"Yes,"* said the student. *"There is a very basic measurement method that you will like. In this method, you take the barometer and begin to walk up the stairs. As you climb the stairs, you mark off the length of the barometer along the wall. You then count the number of marks, and this will give you the height of the building in barometer units. A very direct method.”*

*"Of course, if you want a more sophisticated method, you can tie the barometer to the end of a string, swing it as a pendulum, and determine the value of 'g' at the street level and at the top of the building. From the difference between the two values of 'g', the height of the building can, in principle, be calculated."*

Finally, he concluded, *"If you don't limit me to physics in finding a solution to this problem, there are many other answers, such as taking the barometer to the basement and knocking on the superintendent's door. When the superintendent answers, you speak to him as follows: 'Dear Mr. Superintendent, here I have a very fine barometer. If you will tell me the height of this building, I will give you this barometer.'"*

At this point, I asked the student if he really didn't know the answer to the problem. He admitted that he did, but that he was so fed up with college instructors trying to teach him how to think and to use critical thinking instead of showing him the structure of the subject matter that he decided to take off on what he regarded mostly as a sham.

This student was Niels Bohr (1885-1962), future Danish physicist, who received the Nobel Prize in Physics in 1922.' [24]

Do not 'drag' students to the controlling answer! They can have their own answers that correspond to their knowledge and conceptualisations. It is crucial to teach them to verify the adequacy of their answers basing on comparison of prior and current conceptualisations. We will come to this later.

This aid is a concise guide to the technology of receiving adequate answers. It is absolutely sufficient on the basic stage of education. Yet, one cannot acquire this concise variant without a prior ability of systemic and evolutionary thinking, without understanding such concepts as function, an ideal system or resources for problem solution. Talented thinking is not a set of devices but a single system.

It has been mentioned that besides the basic procedures, there are also supplementary procedures called accelerants. Two of them will be discussed.

One cannot hit even the closest target if one does not know how to shoot. Therefore the last part of the aid is devoted to Talented Education. It cannot be achieved by a 'somersault' or by 'superiors' orders'. Still everything we do gradually accumulates into Talented Education.

One can and must challenge the statements of conceptions. But the arguments must be constructive, every step must be verified, real problems have to be identified and solved. Then this conception will turn into reality.

Let us proceed to the heart of the matter.

# Systemic Thinking – The Basis of Talented Thinking

*The task of this chapter is to develop concepts of the systematic character of the world, to teach to recognise manifold hierarchic relations between objects and phenomena and to understand the regular character of development.*

## Principles of Systemic Thinking

Modern systemic thinking is based on three principles:

1. The principle of hierarchy.
2. The principle of evolution.
3. The principle of emergence / origin.

Let us have a closer look at them.

## Principle of Hierarchy

Consider an ordinary wooden chair. It consists of easily determinable parts – a seat, a back and legs. A more difficult question: what is the purpose of the chair, its function? Students and the audience at workshops usually give an immediate answer – to sit on! But sitting is an action performed by a man, not a chair. What is it that a chair does?

**The function of a chair is to maintain a comfortable position of a sitting person.**

**Example 17:** what is the function of a guitar? No, it is not to play. Only a person can play a guitar. The function of a guitar is to produce particular sounds when a person is strumming its strings. A musician arranges these sounds into music.

**Example 18:** what is the function of formula $E = mc^2$? It explains relationship between the mass and the thotal energy of a body.

**Example 19:** what is D’Artagnan’s function? His function as a literary character is to give the reader an example of a positive romantic hero.

Let us be more specific. Does the seat of the chair fully execute the function of the chair? And its back or its legs? Do they?

Thus any part of the chair separately fails to execute the function of a chair as a whole. This shows that a chair is **a system**.

A new quality and the function of a system are not created by separate parts but by the structure of the system. If we assemble a chair from the same parts but put them together in a different way, we will not create a comfortable chair.

Parts of **a system** are called **subsystems**. Systems consist of subsystems arranged in a certain manner, and this structure allows the system to carry out its function.

**Example 20:** a book has subsequent **subsystems**:

- a cover,
- a back,
- pages (a book block),
- sometimes a dust jacket.

**Example 21:** a river has subsequent **subsystems**:

- water,
- a bed,
- the banks.

We can also consider:

- a headstream,
- an upstream,
- a midstream,
- a downstream,
- the delta.

**Example 22:** a plate has subsequent subsystems:

- a well,
- a lip,
- a rim.

Every subsystem also consists of something. For instance, the back of the chair is made of plywood layers arranged in a particular way, namely, fibres of every layer must be placed crosswise to the fibres of the next layer. The layers will form **the subsystem** of this back and thus will be **the sub-subsystem** of the chair itself.

**Example 23:** pages in a book consist of sheets of paper and signs printed on them.

**Example 24:** water in a river consists of water as a chemical compound ($H_2O$), substances dispersed in it (natural minerals, industrial and household matters) and substances suspended in it (silt, sand, other tiny indissoluble particles).

**Example 25:** a plate's well consists of a disc and a collar-base at the bottom of the disc.

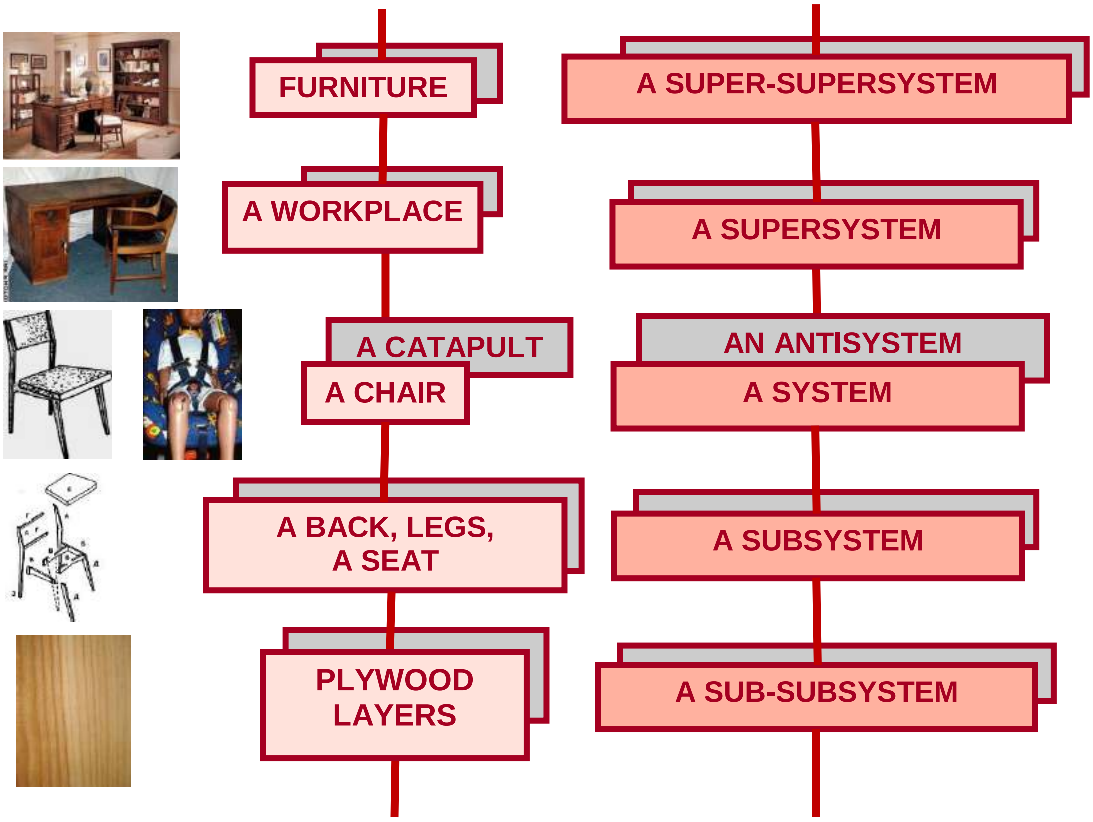
Yet, everything can be viewed from a different perspective. A chair does not function on its own but is part of a more complex system – a workplace. For a user, it can consist of a table and a chair. Here we must admit that a chair is **a subsystem** and its back is **a sub-subsystem**.

Altogether, it makes a **hierarchy of systems**. It is infinite both ways. Plywood layers consist of wooden fibre, which in its turn consists of cells. Meanwhile, a chair is part of a more complex system – a workplace, a dining set or a row of chairs in a hall.

All these stages of hierarchy of systems are called **systems' ranks**.

Besides functions of an object, we can also speak of its **anti-functions**. For a chair, it will be the opposite of maintaining a stable position; namely, throwing a sitting person away. And we do have such a system. It is a catapult, which hurls a person out of an airplane in case of emergency.

Systems that carry out inverse functions, or anti-functions, are called **antisystems**.




It might seem that a hierarchy of systems is an initially given structure. For instance, the Earth belongs to the Solar supersystem, and nothing can be changed.

In fact, it is a bit different. Supersystems do not "exist", they emerge or are created. In "unconscious" nature, supersystems **emerge**.

**Example 26:** about 1.2 billion years ago the Earth was inhabited by very complex yet unicellular organisms. Then they started to join. The earliest known complex multicellular organisms were the so-called Ediacaran biota. They were drops of substance and resembled pouches filled with cellular mash. [92]

But when humans mingle in the chain of events, the process of transition into a subsystem becomes conscious and creative. This way a supersystem **is created**.

**Example 27:** a chair did not and could not exist until Homo Sapiens joined legs, a seat and a back. A supersystem of parts that we call a chair was created.

## Law of Unification

Such artificial unification of systems into a new supersystem is one of the elements of talented thinking.

**Example 28:** at the beginning of the 19th century a French scientist François Aragon wrote a book called "Thunder and Lightning" that contained a few remarks on connection between electricity and magnetism. [40]

This connection was becoming more and more obvious for researchers. Many of them were close to guessing its nature. At an Academy Meeting on September 7, 1758 an academician from St. Petersburg Franz Ulrich Theodor Aepinus presented his treatise "On Congruence of Electrical and Magnetic Forces" where he attempted to apply mathematical reasoning to these subjects. But he lacked a bridge to join the banks, a common denominator…

**Example 29:** in Leipzig, in 1890 Richard Altmann published his "Elementary Organism". Altmann was a histologist – a specialist in anatomy and life of cells. While examining a cell under a microscope, he came to a conclusion that mitochondria were very much like the simplest microorganisms capable of asexual reproduction. [71]

These examples are related to different sciences and to different times but the situations are very similar. In both, there were two phenomena or two objects that had something in common. Nothing was proved at the time but an opinion existed that they should be somehow connected.

Considering these situations today we can say that the opinion was justified. Later, Michael Faraday demonstrated that electric current generated magnetism, and magnetism produced electricity; James Clerk Maxwell developed the theory of electromagnetism. Modern biologists readily admit that mitochondria descended from the ancient microorganisms which had earlier originated as symbiosis of separate unicellular organisms.

At this point we can make a hypothesis that concepts and models are unified. Let us consider other examples of unification from the history of culture.

**Example 30:** until the 18th century purity of genre was one of the absolutes in art. And forbear from mixing the genres! It was for this blending that French Academicians heavily criticized William Shakespeare.

However, the 19th century brought a wave of unification. Novel was an entirely prosaic genre but Pushkin created a novel in verse form. Symphony was an instrumental genre but Ludwig van Beethoven enriched his symphonies with a choir. Scriabin united instrumental music with coloured light projection. Mikalojus Konstantinas Čiurlionis tried to join music and painting. Later, Boris Vladimirovich Asafyev added a choir to the ballet. Fiction was getting more and more filled with documental insertions. This tendency keeps developing.

Unification in the field of technology is quite common too.

**Example 31:** machines and tractors have tandem tyres that improve friction.

**Example 32:** an ordinary bicycle spanner is a unification of a few spanners of different sizes.

Everything in the world is a result of unification. Galaxies are organised into clusters and superclusters. Microorganisms grow together into colonies. Vehicles form traffic systems. Try as they may, linguists cannot prevent unification of languages. Despite the attempts of advocates of racial and national purity, diverse cultures are merging.

**Example 33:** English belongs to the Germanic group of languages but differs greatly from the other languages in the group. Linguists have calculated that approximately 70% of Modern English words were borrowed from other languages.

The Anglo-Saxon tribes that moved to the British Isles in the 5th century A.D. spoke the Proto-Germanic language. In the 11th century England was conquered by the Normans who spoke Norman French. After the invasion, the local language was outlawed in schools, state administration and literature. It facilitated the emergence of a mixed Anglo-Norman language that gradually developed into the Middle English. For instance, the word *calf* has Germanic roots but *veal* was borrowed from the French language much later.

In the 15th century England was already free form the Normans but the new language stayed. It is mostly due to the above-mentioned historical events that English spelling differs greatly from pronunciation. While pronunciation bears the traces of the Proto-

Germanic language, the spelling is predominantly French. There is some reason in the joke about the English language “*You spell Manchester, read it like Liverpool and pronounce it like Birmingham*”.

**Example 34:** the English language is not an exception. Between the $9^{th}$ and 12th centuries the Old Russian language gained much of its linguistic heritage from the Baltic, Finno-Ugric and Iranian tribes. A huge contribution was made by the Mongol-Tatars. In the $13^{th}$ and $14^{th}$ centuries the Russian language was influenced by the Polish and Lithuanian languages but the $17^{th}$ and $18^{th}$ century brought lots of borrowings from the French and Dutch languages. The $20^{th}$ century flooded the language with English borrowings. Yet, the language remains Russian.

There are thousands of examples from different spheres of our life. Unification is the general pass to any kind of evolution or development of natural and artificial objects or to our understanding of them. Unification is one of the mainstream ways of development.

In general, unification is transition into a supersystem. This phenomenon of transition was discovered by G. S. Altschuller in technical systems but it was soon discovered that its application could be extended to any systems of all ranks.

## Principles of Evolution

A chair has not always been a chair. Before being a chair it was a plank and before that it was timber, which was made from trees. After some time this chair will break into pieces, then it might turn into kindling and paper or it might become fuel for a fire or a stove. It will not be a chair forever.

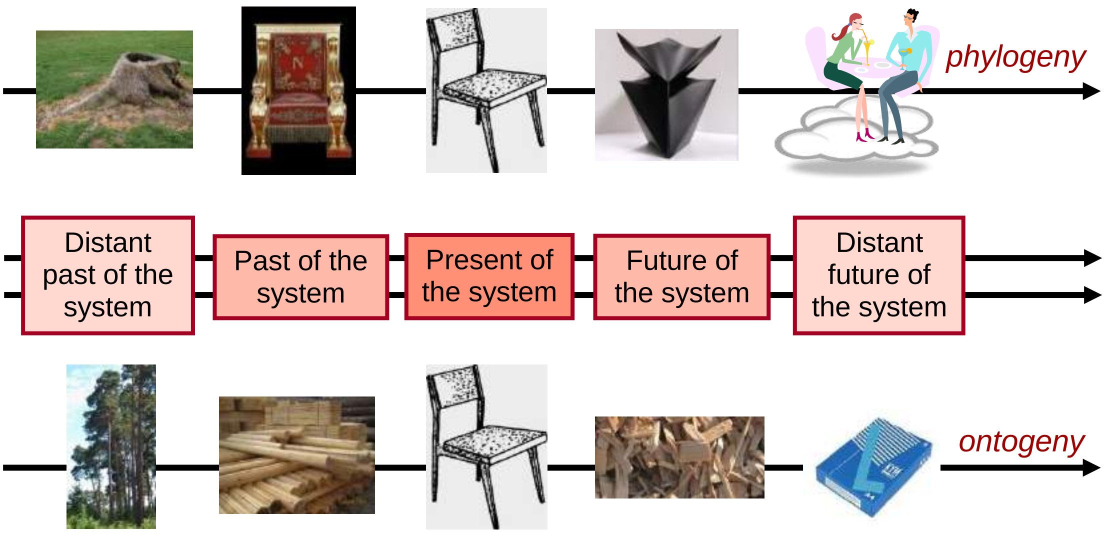
Systems exist in time. They have past (recent, distant), they have future (recent, distant), and they have a short present.

**Example 35:** a book begins with the author`s idea. Then it takes the form of a draft and then it becomes a finished manuscript. Finally, it turns into a book and gets to the reader. Afterwards the book becomes waste paper (and is recycled).

**Example 36:** a river starts in the sky. In the form of precipitation water penetrates the soil. In some places ground waters come out to the surface as brooks. Then, supplied by tributaries and underground springs, the river becomes wider, engulfs various obstacles, washes out its bed and, finally, falls into another river, lake, see or ocean.

**Example 37:** a plate begins with clay. It is extracted from some deposit, then it is mixed with other substances, shaped, fired, coated with a protective or decorative layer and sold to the user. A plate is used for storing food, is put underneath a flowerpot, etc. When it brakes, it is taken to a waste deposit where it slowly decomposes.

Every system exists in two time periods simultaneously: in the time period of the system itself (one system) and in the time period of all the systems of the same kind. Development of one system is called **ontogeny**, but historical development of the whole kind is called **phylogeny**. “A tree → a chair→ kindling” is ontogeny. “A block→ a bench→ a chair” is phylogeny - the historical development of the device for sitting.




**Example 38:** phylogeny of a book. The stories told by *aoidos*, story-tellers and *akyns* were ancient verbal tales, folklore. Then they started carving information in stone, then on pliant materials such as wax and clay tablets, papyrus, parchment. Bound books appeared with invention of paper. Today books are overwhelmingly electronic.

**Example 39:** during a certain period in the history of Earth, there were no rivers. Only the stone sphere existed. Water appeared as a result of volcanic activity and covered the entire surface of the planet with a shallow primitive ocean. Then, as a result of geological processes, land mass emerged from the ocean. At this point water-courses appeared on the surface. Over time the surface of the Earth as well as the rivers changed greatly. Humans changed the system of rivers building dams, reservoirs, channels, creating new riverbeds, etc. This is phylogeny of rivers.

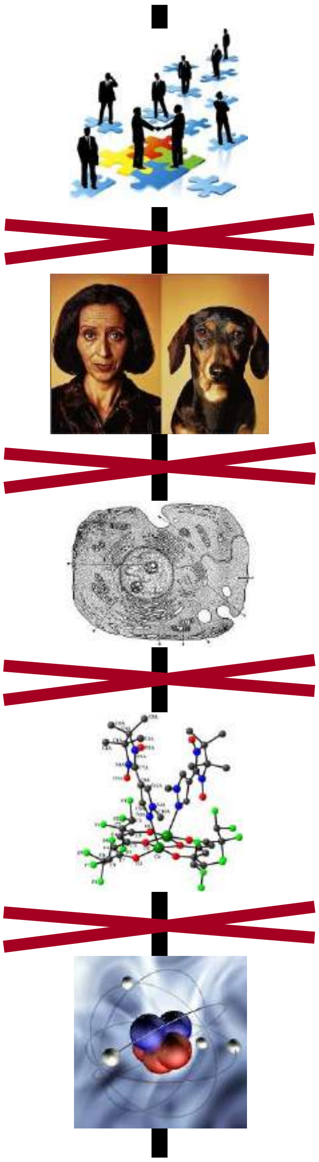
**Example 40:** at first humans ate from their palms, then they started putting food into dried fruit shells and skulls of animals. Archaeologists have discovered dining utensils carved from wood. Then pottery was invented and tableware was made of fired clay. Nowadays plates are made not only of fired clay but also from glass, plastic and cardboard. This is phylogeny of plates.

The main point: systems do not just change their form; they develop according to certain rules. The basic laws of development of systems were discovered by G. S. Altschuller. Talented thinking does not simply change the systems but obeys these laws.

## Principle of Emergent Evolution

The principle of emergence has it that every rank in the hierarchy is governed by its own laws. Let us consider a car. The rank of fuel is governed by the laws of chemistry, the rank of the car as such is governed by the laws of mechanics but the rank of motor transport is governed by the road traffic regulations.

A car is operated not just according to the laws of fuel burning, the same as road traffic regulations do not emerge from the laws of car mechanics.



This pattern shows that laws by which elementary particles compose into atoms have no influence on the laws of molecular functioning. Molecules do not affect functioning of the living cells. The laws of functioning of living cells are not connected with the physiological principles of multicellular organisms, including the man. Human physiology, in its turn, does not explain the rules of the society.

It works both ways. Social rules cannot change the laws of physiology. The atom will not be influenced by any combination molecules may enter.

**Example 41:** in the Middle Ages, there were many theories that tried to explain why local winds blow in one direction. It was believed that winds were caused by rivers and sea streams but these theories could not explain why other winds did not blow along the rivers or did not change their direction.

William of Conches developed a theory that helped to unite winds and streams into a global system. He claimed that there were two streams flowing from the Equatorial Ocean to the West and to the East. His idea was that at the end of the world each stream divided into four currents flowing into the ocean near the North and South Poles. All major winds originated in four places: at both poles and at the spots where the oceans met. Occasionally, one of the currents flowed more intensely than other currents, and the merging spot moved away from the pole. This was his explanation for emergence of supplementary winds. [68]

However naïve this theory might seem, William of Conches made a huge step towards understanding nature. He realised that characteristics of the global systems of water and winds differed from the characteristics of each river or wind in particular.

All in all, systemic thinking is the ability to regard all the systems of this world in their hierarchy and combinations; it is the ability to determine regularities of development of these systems at every rank and the ability to tell the laws of one rank from the laws of all the other ranks. The more systematic our thinking is, the closer we get to talented, genial thinking.

## Practical Tasks Developing the Ability to See the Hierarchy of Systems

Students have to be taught to see the hierarchy of systems as a whole. Thus, it is crucial to teach them to think consistently and be able to draw logical deductions. If the initial system is “a house”, then its closest subsystems will be the walls, the roof, the basement but not the windows or bricks. Windows belong to the subsystem of walls. As far as a house is concerned, they belong to its sub-subsystem.

One must not forbid students to label “unrealistic” supersystems; just the opposite: they have to be praised for it. At the same time students must be offered an opportunity to work out their own answers and to explain why such supersystems are necessary and what is to be done to make them “realistic”.

For example, if students label “transport” as a supersystem for the system “house” and explain that placing a house on a platform allows a person to move without leaving their house, then it is an excellent answer.

Later on these answers can be used as tasks for determining contradictions. For instance, there may arise a contradiction in connection with a house on wheels: one resident of the house wants to go shopping but the other one wants to go fishing at the same time.

Before giving an example of antisystem, a student has to name a property or action of the system for determining the antisystem. For example, "low grass" can be the antisystem for "tall tree". For an action with the meaning "to produce oxygen" the antisystem can be students themselves because humans use oxygen for breathing.

It is crucial to teach students to recognise antiproperties and antiactions, not just other properties and other actions. Antiproperty for "hot" is "cold" but not "warm" or "chilly", and most certainly not "wet".

While concentrating on antiproperties, teachers have to assist students in forming precise, not rough or approximate definitions for these antiproperties. For instance, if a student names a property "hot", the teacher has to ask – how hot? The teacher has to help students express their ideas more specifically: not just say that it is "as hot as water in a tap" but that it is "as hot as fire", "as the Sun", etc. Correspondingly, a student has to define antiproperty – "cold". It is as cold as what? Not just "as cold as water in a tap" but "as cold as ice", "as the Antarctic", etc. At this point the teacher can give general information about the Antarctic. This approach will help expand students' knowledge and improve their ability to imagine properties that are not only domestic but cover the entire world and the Universe.

Below you will find 16 systems for introducing such tasks. Following the example, a teacher can suggest other tasks. Subsequently students can compose such tasks on their own and the exercises can be used in work with other groups of students or younger learners.

In general, peer to peer education is the best way to master a subject, to foster responsibility and to teach cooperation with other people.

**Task 1:** Name basic subsystems, at least one antisystem and five possible supersystems for the systems given below.

1. **Technical:**

    1.1. A watch

1.2. A train

1.3. An apartment

1.4. Traffic lights

2. **Scientific:**

2.1. Chemical formula for water

2.2. Atomic Planetary Model

2.3. Heliocentric Model of the Solar System

2.4. Felidae family

3. **Artistic:**

3.1. Leonardo da Vinci “La Giaconda”

3.2. Genre of music “hard rock”

3.3. Notre-Dame de Paris

3.4. Your favourite poem

4. **Other:**

4.1. Water

4.2. A school

4.3. A continent

4.4. A national costume

## Tasks on Determining Functions of Systems

The students must form a habit of naming a supersystem of any given object before answering the question. A supersytem and its function are given as an example in brackets after every task. Students can offer other supersystems with other functions.

For instance, if a student considers “a rubber” in the supersystem “stationery”, then its function will be “to remove traces from paper”. However, considering the same object in the supersystem “mischief instruments in the classroom”, its function will be “to hit a classmate, who is sitting far away”.

Once the students have mastered the task with traditional supersystems, the teacher should encourage them to look for other, unusual and unexpected supersystems.

It is extremely important to teach students to see the function of the given object and not the function of the object`s user. The function of a desk in the supersystem “office furniture” is “to hold objects on a convenient height” and not “to write”. Writing is the function of a person sitting at the desk.

Another common mistake is to name a secondary function of an object instead of its basic function in the given supersystem. When we consider “a chair” in the supersystem “office furniture”, “to stand” is not its basic function but a supplementary quality.

Once the students have mastered the subject, they can invent similar tasks for their peers.

**Task 2:** Determine functions of the following systems:

1. A pencil (its function in the supersystem of “stationery” is to make traces on paper)
2. A rifle (the supersystem “weapons” – to push out a bullet)
3. A ship (the supersystem “transport” – to carry goods and passengers by water)
4. A knife (the supersystem “tools” – to divide objects into parts)
5. The Periodic Table (the supersystem “chemistry as a science” – to manifest connections between properties of elements)
6. The Multiplication Table (the supersystem “mathematics as a science” – to show the structure of the results of simple quantities multiplication)
7. A dung beetle (the ecosystem – to clean up bio-waste of bigger animals)
8. A cup (the supersystem “tableware” – to retain a liquid without covering it in a position convenient for drinking)
9. A fly (the supersystem “city” – to pollinate urban plants)
10. A needle (the supersystem “sewing tools” – to pierce a fabric and to hold a thread)

These are just some examples of tasks. Teachers have to introduce new tasks all the time. Once the students have mastered the subject, the teacher should ask them to invent such tasks on their own.

## Tasks on Unification of Systems

**Task 3: t**ake any dictionary and choose two random words that name any specific objects. Try to unite these objects into one system. What are the new possibilities that stem from this unification?

(While performing this task, one should not ponder over the reasons why this unification would not result in anything new and interesting. On the contrary, one should focus on looking for new results and proofs of such possibilities.)

**Task 4:** name the already existing examples of unification of a pencil with other objects. What are the new possibilities of this unification in comparison with a pencil as a separate object?

**Task 5:** think of new, non-existent supersystems for a pencil. What objects could be united with a pencil? What would the advantages of the new supersystem be?

**Task 6:** houses in the early settlements were built chaotically, but gradually humans realised that it was more convenient to arrange houses according to a common plan – they were united into villages and cities. What were the new possibilities provided by this unification?

**Task 7:** a new plant emerges from unification of parent plants' genes by means of pollination. A new organism (also a human being) is formed by unification of parents' genes. Today artificial combination of genes is possible. What are the new positive possibilities and advantages of this discovery?

**Task 8:** unification of music and poetry resulted in such new genres as songs, cantatas and operas. Unification of painting and theatre resulted in emergence of settings, decorations and stage design. What forms of art have not been unified yet? Suggest a possible unification. What are the new expressive possibilities created by such unifications?

## Tasks on Evolution of Systems

The first group of tasks will contain ontogenetic processes. The aim is to find at least one phylogenetic process. Let us consider one example.

**Task 9:** the weather changes all the time. What phylogenetic process is related to this process?

**Solution:** the weather is one notion, but all weather conditions in a considerably large area during a long period of time form a climate. Historical climate change is a phylogenetic process in relation to the weather.

**Task 10:** school curriculum changes from the first form to the last. What phylogenetic process corresponds to this process? (*Historical changes of the school curricula*).

**Task 11:** child's conceptualisations change from infancy to youth. What phylogenetic process corresponds to this process? (*Historical changes of conceptualisations of the human kind*).

**Task 12:** the process of building a house. What phylogenetic process corresponds to this process? (*Historical changes of the building process*).

**Task 13:** the process of decorating a house. What phylogenetic process corresponds to this process? (*Historical changes in the art of architecture*).

**Task 14:** the process of writing a book. What phylogenetic process corresponds to this process? (*Historical changes in the literature*).

**Task 15:** the process of publishing a book. What phylogenetic process corresponds to this process? (*Historical changes in the publishing industry*).

The second group of tasks will contain phylogenetic processes. The aim is to find at least one relevant ontogenetic process.

**Task 16:** the process of domesticating wild potatoes has been studied in the finest detail. What is the ontogeny in the given case?

**Solution:** the history of the potato plant is the history of domesticating the entire crop. Thus the ontogeny is "the history" of a particular potato plant – from planting until harvesting tubers.

**Task 17:** development of transport. What is the ontogeny in the given case? (D*evelopment of a particular type of transport, for example, a car or a train*).

**Task 18:** development of a car. What is the ontogeny in the given case? (*"The life" of a particular car from its production to utilization*).

**Task 19:** development of writing tools. What is the ontogeny in the given case? (*The history of development of a particular tool, for example, a pencil or a pen*).

**Task 20:** the history of a pencil. What is the ontogeny in the given case? (*"The life" of a particular pencil from production to utilization*).

**Task 21:** development of plants. What is the ontogeny in the given case? (*The history of a particular type of plants, for example, trees or bushes*).

**Task 22:** development of trees. What is the ontogeny in the given case? (*"The life" of a particular tree from a seed to its death or logging*).

**Task 23:** the history of human diseases. What is the ontogeny in the given case? (*The history of development of a particular disease*).

## Problem Solving

*This chapter is devoted to the general rules of contradictions analysis*
*and methods of solving contradictions*
*basing on the principles of systemic thinking.*

During their lifetime human beings face millions of problems in different spheres – from their household to science, technology, art, administration, etc. The ability to solve contradictions is one of the core qualities of a talented human. To be able to solve contradictions a person has to understand their causes and structure, analyse them and know the techniques of solving them.

## Wave of Problems

It has already been shown that any system permanently or at a sequential step is part of a number of various supersystems. Moreover, humans themselves introduce systems into already existing supersystems or create new supersystems.

Every supersystem has its own requirements with regard to the systems that compose it. Let us consider a chandelier as incorporated into the supersystem “light fittings”. This supersystem requires such qualities as ability to produce very bright light and illuminate the furthest corners of any room.

However, the requirements of various supersystems are rarely the same. The above-mentioned chandelier can also be an element of a family budget. The budget requires the lowest possible consumption of electric energy; so the device has to produce very dim light.

This is a contradiction.

Considering any problem one can conclude that problems arise from the diverse requirements of systems. Problems are not created by unkind people; they result from incongruous requirements of diverse supersystems towards one particular system.

Contradictions must be eliminated in every sphere: technology, science, art, administration, law…

**Example 42:** aboriginal tribes considered their territory sacred and inviolable. Strangers who dared enter the tribal territory were often killed. Still, for various reasons it was sometimes necessary to pass through the alien territory. Thus there is a catch: **unfriendly territory has to be and must not be inviolable at the same time**. What can be done?

(*Some tribes in different parts of the world solved this problem in the following way: they assigned special pathways that strangers were allowed to use*.) [42]

**Example 43:** the Bacchanalia festivals were most popular with the people of Rome but they were very inconvenient for the authorities. Continual festivals included excessive drinking, profligacy and conspiracies against the state. The Roman Senate attempted to prohibit Bacchanalia under the threat of death penalty. Yet, it appeared that many of the participants of the festivals were women but in ancient Rome every woman was a property of a man. **Women, alongside with men, had to be put to trial; at the same time it was not possible to try them as they were just men`s property.** What could be done?

(*The contradiction was eliminated by entrusting executions to women's male relatives. A husband had to execute his wife, a father - his daughter, and a brother - his sister*.) [21]

**Example 44:** while studying magnetic properties of gases, Michael Faraday faced a problem. Gases were invisible, and it was not possible to determine whether they were attracted to magnets or not. No doubt, one could add some visible substance such as particles of dust or smoke to the gas but then again it would not be possible tell what exactly was attracted to the magnet: the gas itself or the substance it was mixed with. Thus, **a gas had to be visible; still it could not be visible**.

(*Faraday solved this problem. He blew the gas through a solution of soap (obviously non-magnetic), and soap bubbles with magnetic gases were attracted to the magnets.*) [51]

**Example 45:** in a film, its director had to shoot an episode showing a huge ball. Hundreds of couples were supposed to dance in a giant hall. However, the film studio could afford only a small room and five couples of dancers. **The director had to film an episode with many dancers when he could afford only a few couples**.

(*He solved this problem by surrounding dancers with mirrors and thus created a magnificent ball*.) [43]

A contradiction must not remain unsolved. If it does, it will only grow and become a disturbance that will create obstacles and spoil the situation.

**Example 46:** at the end of the 16$^{th}$ century artists started covering canvas for their paintings with colourful priming, which enhanced the contrast of colouring and its dynamics but reduced the durability of the paintings. This problem could not be solved at that time. Baroque paintings came to us in a much worse shape than those of Quattrocento, which had been created earlier. Restoration of baroque paintings requires significant effort even today. [20]

This is one of the already mentioned laws. Altschuller called it **the law of uneven development**. This law states that different parts of a system develop at different rates, which leads to contradictions.

The more solutions there are, the more new problems arise. The wave of problems rushes like an avalanche! The ability to eliminate contradictions in a consistent and prompt manner is another indispensable quality of talented thinking.

There is no sphere of our life where problems and contradictions would not appear regularly. This ever rising wave cannot be stopped because it is an integral part of human life and of the entire Universe.

Nonetheless, contradictions cannot be eliminated by speculation. They can only be dealt with by applying reliable methodology. Such methodology was developed by G. S. Altschuller and is called TRIZ – the Theory of Inventive Problem Solving. This theory has been thoroughly described in many Altschuller's books, the works of his students and his followers.

## Problem Analysis

Let us consider a specific example.

**Example 47:** huge power plants have to be equipped with 12- metre high porcelain insulators. Production of such enormous parts requires huge calcination furnaces and much fuel. A standard furnace can only kiln two to three metres high insulators. What can be done?

These are students` answers before they started studying the principles of elimination of contradictions:

- to build a huge furnace;
- to make insulators from another material that does not require kilning;
- to calcinate only rims of insulators.

All the three solutions are unduly expensive and they fail to solve the problem.

In practice the problem consists of **two requirements**. **The first one** is specified by the power plant: it must be equipped with huge insulators. **The second** is set forth by the calcination furnace: it can hold only small insulators.

As has been mentioned, all problems arise from incompatible requirements of two supersystems towards one particular system.

These are called **contradictory requirements (CR)**. The formula of CR:

**IF** (one requirement is fulfilled), **THEN** (a positive consequence), **BUT** (a negative consequence).

**CR-1: If** *a huge insulator is produced*, **then** *it will be suitable for the power plant*, **but** *it will not fit into the calcination furnace*.

The same contradiction is in the second requirement:

**CR-2: If** *a small insulator is produced*, **then** *it will fit into the calcination furnace*, **but** *it will not be suitable for the power plant*.

In fact, the essence of the problem lies within **the insulator**: it has to be **big** and **small** at the same time – but this is impossible. The problem cannot be solved because of the natural properties of the insulator.

An object in the centre of the contradiction that cannot fulfil the requirements of the supersystem is called **an instrument**. It is characterised by incompatible qualities. It goes as follows:

**An instrument** – insulator (big, small)

Here comes a deeper understanding of the problem that concerns properties of the object. Let us put it into a standard formula of **contradictory properties (CP)**:

(*instrument*) **HAS TO BE** (*a property*), **IN ORDER TO** (*fulfil **the first** requirement*), and **HAS TO BE** (*contradictory property*), **IN ORDER TO** (*fulfil the second requirement*).

**CP:** The insulator **has to be** *big*, **in order to** *be suitable for the power plant*, and **it has to be** *small* **in order** *to fit in the calcining furnace*.

## Principles of Separation

G. S. Altschuller realised that all contradictions may be resolved through the agency of a few standard procedures. In fact, the task is to separate incompatible properties so that they do not interfere with each other. [11] Let us consider the most common ways of doing it.

1. **Separating contradictory properties in space.** It means that one part (or a group of parts) will have one property and the other part (group of parts) will bear a property opposite to the first one. In other words, one property will be in one place (places) and the other one will be in another place (places).

**Example 48:** Roman style in architecture is known for its thick, massive walls and heavy horizontal structural frames. The 12$^{th}$ century brought the ideas of spiritual upswing and might of human mind, and these ideas could not but expand into architecture. The simplest response from the architects was to build light, thin walls. Yet such walls would not bear heavy horizontal structural frames, and contemporary technology could not offer any other type of construction. **The wall had to be thick to be able to bear horizontal structural frames, and it had to be thin in order to manifest the new ideas.**

Architects eliminated this contradiction by dividing a wall into two groups of parts. Some parts remained thick, while other parts became thin. All these parts were arranged alternately: thick – thin, thick – thin. Thick parts took on the load of the structural frames, whereas thin frames manifested lightness of the entire construction. [4]

**Example 49:** Ancient Greeks were convinced that Gods could not create anything inharmonious, unstable or unattractive. So, the world had to be beautiful, stable and orderly. However, the real world failed to meet these demands; there was very little order in it, it was constantly changing, and not for the better. **The world had to be harmonious in order to comply with the virtues of Gods, and at the same time it had to be inharmonious to conform to the reality.**

The same mechanism as above was used to resolve this contradiction. Greeks divided the world into two parts: heavenly and earthly. The heaven was harmonious and governed by severe laws. The Earth, on the other hand, was created imperfect and chaotic to make people aspire to harmony. [7]

2. **Separation of contradictory properties in time.** It means that the system at some particular time has one property but at some other time it acquires a contradictory property. These properties may appear alternately.

**Example 50:** while studying the Ancient Roman mythology, historians faced a problem. Mars was God of war. Wars were fought only in summer, after the crops were harvested and the army could be provided with food. On the other hand, Roman months were named after Gods, and the first month of spring, March, was named after Mars. However, there were no crops to harvest in March; subsequently wars could not have been fought at that time. **Mars had to be God of war to correspond to the well-known mythology, and he had to be a non-military God for his name to be given to a spring month.**

Anthropologist James Frazer offered a suggestion that at first Mars was God of flora but later became a military God. The research on early mythology confirmed this suggestion. [89]

**Example 51:** One of the trends among rock musicians in the 1960s was destruction of musical instruments after the concert. An English rock band *Deep Purple* also decided to follow the custom but their guitarist Ritchie Blackmore was so fond of his modern and expensive guitar that he did not want to smash it. Thus, **a guitar had to be expensive in order to satisfy Blackmore but it had to be cheap to be smashed without regret.**

Musicians “separated” the guitar in time: at the end of the show Blackmore discreetly changed his expensive guitar for a cheap one which looked exactly like Blackmore’s guitar. [88]

3. **Dividing contradictory properties between the system and the subsystems.** It means that the entire system has a particular property but its subsystems, or parts, have some contradicting property.

**Example 52:** Today, insulators for power plants (Example 47) are assembled from a number of small parts which are calcined separately and are glued together afterwards to form one huge insulator. [34]

**Example 53:** Finnish architect Reima Pietilä signed a very prestigious contract: he was supposed to design a governmental building for Kuwait. Kuwait is an Arab country with its own architecture that is characterised by curved shapes; Pietilä as a typical European architect was used to employing straight and angular forms. **The shape of the building had to be curved in order to fit into the local architecture, but it had to be rectilinear to facilitate the architect's projection process.**

Pietilä designed all the building in the shape of small rectilinear constructions but arranged them in a way that created impression of a curved shape. [2]

**Example 54:** In 1827 a Scottish botanist *Robert Brown* decided to examine grains of pollen of the plant Clarkia Pulchella under a microscope. In order to ensure a plain surface that would reflect light he put the grains of pollen on the water surface. Unfortunately, it proved to be impossible to study the pollen this way because its cells were constantly trembling and moving. This phenomenon was called Brownian motion, but scientists at that time could not explain the source of the motion in seemingly immobile water. **Water had to be mobile in order to explain the motion of pollen, but had to be immobile to correspond to the observations.**

This phenomenon was explained by Albert Einstein in 1905. He supposed that pollen was pushed by moving water molecules. The molecules moved while the water itself remained still. [9] This phenomenon can be observed in the following video: http://www.youtube.com/watch?v=cDcprgWiQEY

Look at the dates. I t took almost 80 years to resolve this contradiction though at Mr. Brown's time molecules were already known. 80 years delay is the price paid for inability to solve contradictions.

4. **Dividing contradictory properties between the system and supersystem.** It means that the system has to be united with two or more systems so that the system itself will keep demonstrating one property, but the whole unified supersystem will manifest another property. Not only similar but also diverse systems can be united.

**Example 55:** Landing a heavy aircraft requires durable surfacing of the runway that is usually made of special types of concrete. But how shall aircraft land in the Antarctic? It is not possible to deliver enough concrete to the Antarctic. Firmly tamped snow can be used as surfacing. There are two types of snow in the Antarctic: usual snow consisting of flakes and the so-called firn, which is granular snow. Snowflakes can be easily tamped, but the coating they make is not firm enough to bear the weight of aircraft. Firn, on the other hand, is extremely durable and can easily bear a plane, but it cannot be packed. **The snow has to be flaky to be easily tamped but it has to be firn-like to bear aircraft.**

Today runways in the Antarctic are made of a mixture of snow and firn. The two ingredients are mixed together and the mixture is tamped resulting in a fine and solid runway. [65]

**Example 56:** Theatrical plays always had one main hero and some secondary characters. It was a compulsory rule for all playwrights. In antique plays there was a limited number of characters; nowadays the variety of human types is so big that a play cannot embrace this diversity. **The main hero is expected to be "versatile" to reflect the diversity of characters; at the same time he or she must be "uniform", integral to look natural.**

Russian playwright Anton Chekhov was the first to start writing plays with several main heroes. As a result, there appeared both a natural personality as a separate character and diversity as a system of the main characters of the play. [77]

5. **Dividing contradictory properties between the system and the antisystem.** It means that the antisystem (a system with inverse properties, functions, etc.) has to take place of the system or be united with it. As far as the process is concerned, it has to be conducted inversely – from the end to the beginning.

**Example 57:** In war films characters that are being killed fall over turning around their axis. But in reality people who are dying in the battle do not fall over this way; it is just a trick for an actor to avoid being hurt when they hit the ground. For those who know it such fall seems unnatural. Thus, **the fall of the body has to be rotating to spare the actor, but it has to be straight to look right.**

In general, rotation is viewed in relation to the surrounding environment. When shooting the film "Cranes Are Flying", Russian operator Sergey Urusevsky substituted antisystem for the system – he filmed the episode as rotation of the surrounding landscape around the killed character. [53]

**Example 58:** Floating ice often damages bridges on small rivers. Low wooden bridges are simply swept away by the mass of floating ice; building high bridges on small rivers is uneconomical. Thus, **a bridge has to be low in order to be cheap, but it has to be high to let the floating ice pass under it.**

One of the inventions aimed at solving this contradiction suggests building very low bridges. Before floating ice reaches the bridge, it is entirely covered by a plate slab one of the ends of which slides down into the water. The floating ice literally crawls over the bridge. The system "ice over the bridge" substitutes for the system "ice under the bridge". [33]

6. Dividing **contradictory properties by means of phase transition.** Common examples of phase transition include melting (transformation of solid into liquid), condensation (transformation of gas into liquid) and solidification (transformation of liquid into solid). Some less common examples are evaporation of solids and transformation of gas directly into solid (sublimation). For instance, at low temperatures ice turns into gas easily; naphthalene vapours turn into crystals omitting liquid phase. The idea can be used in technology. This phenomenon can help interpret inexplicable phenomena in science.

**Example 59:** Computer parts are joined by connectors or the so-called conductive contacts. The smaller the parts, the smaller connectors are used because big connectors have high reactance. Cryogenic computers that are used at ultra-low temperatures have very small parts which require adequate connectors. Such connectors are extremely difficult to produce, and to insert them between the details is next to impossible. Thus, **a connector has to be large enough to be inserted properly, and has to be small enough to have low reactance.**

The contradiction was eliminated by changing the phase state of the connector. Let it be liquid and then change into a solid! While assembling cryogenic computers, the details are connected with a microscopic drop of mercury between them. Mercury is a metal and makes an excellent conductor. At operating temperatures mercury becomes solid and forms an ideal connector with low electrical reactance. [41]

**Example 60:** During numerous research expeditions in the Alps scientists discovered huge amounts of mineral that resembled pumice. Pumice is formed at the temperatures of volcanic lava. The problem is that the Alps are not volcanic mountains; there has never been a single volcano. Where did the super-heated liquid streams that gave birth to pumice come from? **Thus, rocks have to be melted in order to create pumice and they have to be solid because there have never been any volcanos.**

Again the answer is in phase transition. During an avalanche thousands tons of rock rush down the slopes and the friction of this enormous mass against hillsides rises temperature so high that the lowest layer of the avalanche melts and pumice is formed.

7. In art (sometimes in science as well) an extremely common method is separating **contradicting properties by contrast**. The initial system has a property, but in comparison with another (reference standard) system it is an inversed property.

**Example 61:** One of the Beatles` compositions, “A Day in a Life” incorporates excerpts from news about a car crash, about war, and about bad condition of British roads. These facts are given in a hackneyed journalistic manner, and the song resembles a parody of the newspapers. Still, it was necessary to stress the horror of the car crash, the inhumanity of war and the indifference of the authorities towards the dreadful condition of the roads. Thus, **the news has to be “terrible” in order to emphasize its inhumanity and it has to be hackneyed to parody the newspapers.**

To solve this contradiction John Lennon finishes each of these stories written in the hackneyed newspaper style with an unexpected and “inappropriate” phrase: “I’d love to turn you on”. It was the contrast with this seemingly silly phrase that made the preceding story still more terrible.

## Tasks Concerning Systemic Search for Solutions

**Let us practice together.**

**Task 24:** In one of the short stories by Sir Arthur Conan Doyle, “Disappearance of Lady Frances Carfax”, criminals kidnapped an elderly rich single woman and planned to get rid of her. Sherlock Holmes was informed that they had ordered a coffin. It was obvious that the criminals wanted to bury the lady. However, in the evening, when Holmes rushed into the house and opened the coffin, he discovered a dead woman, who was the criminals' servant. Using the rest of the clues Holmes guessed all the details of the criminal plan. So how did they plan to get rid of Lady Carfax?

First of all, the task is to be solved from the perspective of the criminals. They suspected that Holmes would discover their plan and would come to check the coffin; it was too late to cancel the burial of Lady Carfax under the guise of their servant. They had only one solution – **to use the factor of time**. The body of the dead servant would stay in the coffin for the whole time of the inspection, but at the last moment before the burial it would be changed for Lady Carfax. [38]

Below find a few tasks for independent solution.

**Task 25:** Artificial marble is produced from concrete mixed with natural marble chips. After hardening, the concrete looks almost like natural marble. It is very convenient because tiles and slabs of any size and shape can be formed. The drawback is that concrete is very hard, and the slabs are difficult to polish.

Is there a way to produce a polished slab of artificial marble without additional time and labour input?

All peculiarities of systemic approach have to be borne in mind.

*(You should look for help in the supersystem. The closest element of the supersystem is a form which is used to make slabs of artificial marble. If the bottom of the form is smooth enough, the surface of the slab will also look polished. There was also a suggestion to put a glass sheet on the bottom of the form.*) [32]

**Task 26:** A classical detective story is based on the plot where a clever detective catches a crafty criminal. Detectives never join their efforts with the police, and criminals can have no more than two assistants.

Predict further development of the character of the criminal in the framework of a classical detective story.

And again, the answer lies within the hierarchy of systems.

(*In later detective novels, the detective would join his efforts with the police. In some others, like in George Simeon`s novels, the detective is a policeman. Criminals also evolved into supersystem; for example, in Rex Stout`s and Earle Gardner`s novels detectives had to fight against an entire criminal organisation*.)

**Task 27:** The Medieval map of the world created by Lambert of Saint-Omer depicts a huge Southern continent. The comment suggests that "if there is summer in our area, there is winter in theirs". In the Western Hemisphere, there is a large island. This region is provided with the following comment: "This land is inhabited by our antipodes, and their nights and days are opposite to ours".

Considering the fact that earlier there had been much debate on the existence of antipodes as such (the Church held it that it was a sin to believe in antipodes), what systemic transitions were made by Lambert of Saint-Omer?

(*He made two transitions to the antisystem. Firstly, Lambert inversed the seasons; secondly, he inversed the day and night*). [67]

**Task 28:** People living along lakes in cold latitudes know that while freezing these water basins produce humming noises. A medieval scientist Gerald of Wales compared these noises to howling of large herds of animals. He gave an explanation of this phenomenon, which is considered to be right even now.

Try to explain this humming noise. What kind of systemic transitions will have to be made in this case?

(*Gerald of Wales found the reason in the supersystem. One of its elements in case of the lake is the air. Motion of the air under the freezing ice is the reason for the humming noise*). [70]

**Task 29:** While studying current flow in various substances, Faraday noticed that water had very high electrical conductivity, whereas ice did not conduct electricity at all. But water and ice were the same substance!

Which systemic transition can explain this paradox?

(*The explanation lies within the subsystems. Faraday made a proposal that frozen particles of water link together tightly and stop conducting electrical current*.) [49]

**Task 30:** Rhyme is one of the strongest types of rhythm in poetry. It is especially preferable in dramatic poetry. Still, in many situations the character's poetic speech may sound unnatural. In such cases rhyme can be a disturbance. It adds clarity to the actors` dialogues but "rhymed" speech is completely unnatural.

The 18th century playwrights solved this problem. Part of the characters' monologues was written as rhymed while the other part had no rhyme. Let us consider an example from Shakespeare:

*For 'tis the sport to have the engineer*

*Hoist with his own petard: and 't shall go hard*

*But I will delve one yard below their mines,*

*And blow them at the moon: O, 'tis most* ***sweet****,*

*When in one line two crafts directly* ***meet****.*

**("Hamlet", Act III, Scene 4.)** [94]

What systemic transition was applied to solve this problem?

(*The monologue was divided into two subsystems – the rhymed and the unrhymed one*.)

**Task 31:** In his novel "War and Peace" Leo Tolstoy wanted to create a possibly full picture of the Battle of Borodino through the eyes of very different characters – from militarily brief Kutuzov to verbose Bezukhov, from professional Napoleon to sober-minded Bolkonsky. Such description would take much time and space in the novel, but a battle is a short and dynamic event.

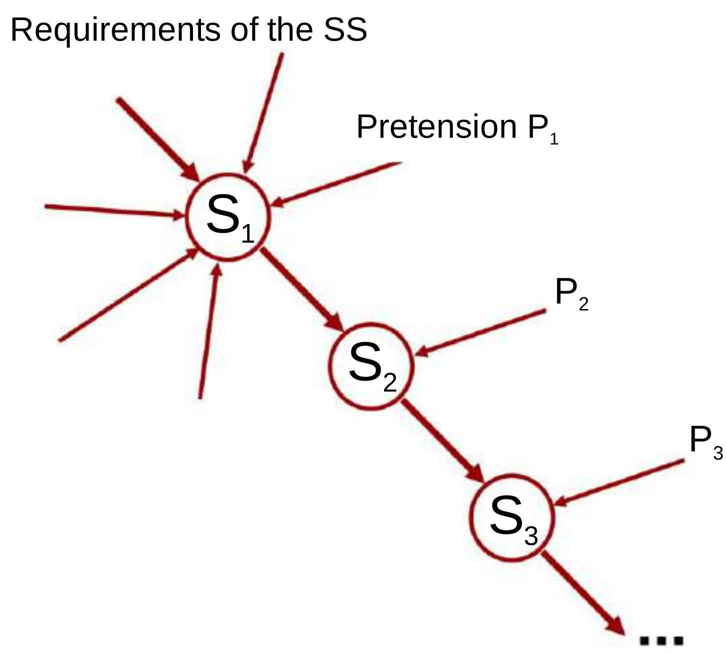
What is the best way to show both the dynamism of the battle and most versatile views of it? What transition can be applied?

(*Tolstoy introduced different timing. The battle was partly described before it actually happened in the form of military plans, disposition, etc*.)

## Chains of Problems

Talented thinking is not only about solving problems but it is also about foreseeing the consequences of these solutions. What happens to the solution next?

Suffice it to say that every situation has its positive and negative sides. This is the basis of the contradictory requirements formula. Thus, any our solution creates a new situation which will have its positive (the first problem is solved) and negative (another problem arises) sides.  Every solution triggers a new problem.




**Example 62:** We have already discussed Example 48 about the stone temples in Europe. The first idea that architects tried to realise was to make the walls less massive, thinner and optically lighter. However, they immediately faced a problem: thin walls could not bear heavy horizontal frames, which were the only frames known at that time. Contradiction: a wall had to be thick to bear horizontal structural frames and had to be thin to manifest the idea of levitation.

The contradiction was solved by division of the elements in space: thin and thick parts of the walls were arranged alternately. Thin parts symbolized airiness, whereas thick parts took on the load of the structural frames.

A new problem arose immediately: due to the darkness in the church one could not notice the airiness of the walls. It was solved by enlarging windows.

But again, it was not possible to enlarge the windows considerably between the thick spaces of the wall. This problem was solved by separating thick parts from the wall itself, namely, architects re-invented the columns that had been forgotten all the time after destruction of the pagan antique cultures.

Windows became still larger, which made churches vulnerable to winds and winter cold. By that time glass was already known. However, the available technology allowed producing not the desirable big glass panels but only small pieces. Thus, glass panels had to be big enough to cover a window; at the same time glass pieces had to be small to be produced.

The contradictory properties were distributed between the system and subsystems. The entire glass panel would be big, but it would be made of small pieces of glass held together by leaden strips.

The available technology did not allow producing equally transparent pieces of glass; as a result, big glass panels failed to look beautiful. A decision was made to benefit from the different degree of transparency: pieces of glass were deliberately produced with diverse transparency and colouring. It enabled artists to assemble pictures – transparent mosaics.

Emergence of a new style in architecture, the Gothic style, was gradual and was arrived at through the painful process of resolving contradictions. It was not immediately recognised, which is clear from the very name of it. At that time Goths were uncivilized barbarians, so the new style was also considered barbarian. Centuries had passed from the first attempts to make the walls lighter before Gothic became a refined architectural style. These centuries were marked by a chain of emerging and solving contradictions.

G. S. Altschuller called this regularity **the law of uneven development of systems,** and it is true for evolution of any kind of systems.

This is why everyone must be able to eliminate contradictions in a quick and qualitative manner. Like it or not, nothing can change the fact that problems appear like an avalanche, and there are not enough “natural” talents and mythical “gifted children” to solve all the arising problems. And there will never be!

**Example 63:** How many diseases are there in the modern world?

World Health Organisation (WHO) has described a few thousand of diseases.

Doctors consider that $10^7$ to $10^8$ (from dozens to hundreds of million) of deviations in our organism are diseases.

In general, there are $10^{34}$ (ten decillions) of different deviations known these days, such as, for example, patellar dislocation as a result of a car crash. [82]

**How many talented doctors, in your opinion, are necessary to develop methods for curing all these diseases?**

**Example 64:** How many inventions are registered around the world?

In 1987 there were:

In USSR – 83.7 thousand,

In USA – 82.9 thousand,

In Japan – 62.4 thousand,

In Germany – 28.7 thousand,

In UK – 28.7 thousand registered inventions.

Having said that, specialists admit that a considerable part of these inventions come in late, meaning that they had been urgent long before their presentation. [91]

**In your opinion, how many talented inventors do we need to solve all technical problems?**

**Example 65:** How many names of books are published annually?

In1952 – 250 000,

In 1962 – 388 000,

In 1972 – 561 000,

In 1981 – 729 000,

In 2000 – 1.25 million. [81]

And these are only literary works. However, do all these books have high artistic value?

**How many talented artists are necessary to satisfy the need of the humanity for real art?**

If we take into consideration the fact that demand for talented discoveries, inventions, art works, administrative, economic and other solutions also grows like an avalanche, we can see that the only way out for the humanity is to make every single person maximally genial.

## Tasks on Contradictions Analysis and Solution

**Task 32:** Many of the most horrible fires that have brought grieve consequences are the fires during emergency landings of aircraft and helicopters. It is aviation fuel that burns and such fires cannot be put out with water; so fire-fighters have to use foam. Still, it is not all that simple.

Foams with small air-filled bubbles (low-expansion foams) can quickly cover large areas of fire pressing it away from the surface of the burning liquid; but these foams are not stable, decompose very quickly and allow fire to regain part of the surface catching flames from the neighbouring burning patches. Foams with big air-filled bubbles (high-expansion foams), on the other hand, are good at protecting the surface of the liquid from catching fire again but is useless with open flame.

How can such fire be extinguished then?

*(The solution was found in transition to the supersystem. The fire is suppressed by both types of foam that are directed so that they get mixed on the fire site.)* [46]

**Task 33:** Jainism is one of Indian religions. Among other elements, there are protective ghosts, or *Bhairobi*. Jain temples are supposed to have statues of these ghosts.

Any religion has ghosts, and to make them recognizable they are usually made manlike. Christian angels and daemons, Islamic genies and shaitans are all manlike. However, one cannot create a manlike sculpture of *Bhairobi:* according to Jain beliefs, *Bhairobi* ghosts are shapeless. But looking at a shapeless sculpture one would not be able to recognize it as a ghost.

How shall they present *Bhairobi*?

*(The solution is distribution in space – the lower part of the sculpture is shapeless but the upper part resembles a human face.)* [86]

**Task 34:** In the classical planetary model of an atom a kind of shell consisting of electrons is rotating around the nucleus. The number of electrons in this shell is equal to the charge of the nucleus, that is to the number of the element in Mendeleyev`s Periodic Table. Hydrogen shell contains only one electron, oxygen shell has eight, but lead shell is circulated by 82 electrons.

Atoms can form chemical compounds by blending their electrons which become common for both nuclei. But even school pupils know that only some electrons get blended, and their number is equal to the valence of the atom. Thus, the valence of hydrogen is 1, of oxygen it is 2, lead has a valence of 4. It means that six out of eight electrons of oxygen demonstrate no wish to participate in the blending process. Lead has as many as 78 “abstaining” electrons.

What is the explanation?

(*It lies in transition to the supersystem. An atom has a number of electron shells at different distances from the nucleus, but only electrons of the outer shell participate in forming compounds*).

**Task 35:** When filming “Hamlet”, Russian film director Grigori Kozintsev and costume designer Simon Virsaladze pondered over a costume for Prince of Denmark. It was quite possible to reproduce the original costume of Hamlet`s epoch, but in the director`s conception the film was to be modern. It was unreasonable to shoot a documentary about Hamlet that would be interesting to no one but historians. However, they could not dress the character in accordance with the standards contemporary with the time because everybody knew what the fashion was like in Hamlet’s days.

So, what was Hamlet to be wearing in the film?

(D*istribution of contradictory properties between the system and its subsystems. The costume consisted of modern details but its general silhouette was medieval.*) [42]

**Task 36:** mutation is the result of errors in the process of DNA replication and can be caused by such factors as radiation, viruses, chemical interference, etc.

There is an abundance of factors, yet the number of mutations is considerably smaller than it might be expected according to the mathematical calculations.

What is the explanation?

(*It lies in unification with the antisystem. Apart from the mechanism of mutations there should also be an anti-mutation “repairing” mechanism*). [72]

**Task 37:** a number of medieval scientists (such as St. Basil the Great, St. Ambrose or St. Augustine) made an assumption that tides were caused by the gravitational forces of the Moon. However, in the 7th century another Augustine brought it to notice that tides did not exactly correspond to the Moon phases. During the year they either diverged from the Moon cycles or returned to their usual motions.

What is the explanation?

*(Transition to the oversystem. Influence of the Moon is combined with the influence of the Sun).* [66]

**Task 38:** a ship propeller rotates, its blades push water away, and the ship moves forward. But its motion is not entirely straightforward. Due to rotation of propellers the ship gets slightly off its course which must be constantly corrected, so the ship makes zigzag movements. If the propeller blades are turned so that they rotate in the opposite direction, the ship deviates to the other side.

How can we achieve direct motion of a ship?

(*The solution is in transition to the supersystem. It was proposed to install two propellers on one axis which would rotate in opposite directions. Not only did the solution eliminate deviations but it also significantly improved braking efficiency.*) [31]

**Task 39:** surfaces of some big parts are processed by soaking them in a bath with aggressive electrolyte. While evaporating, the aggressive solution poisons the air in the manufactory; once the bath is covered with a lid, it is not possible to put in new parts.

So, how do we ensure operation of the manufactory without poisoning the air with the electrolyte vapours?

(*The contradiction is resolved between the system and subsystems. In conformity with the Author's Certificate No 1 092 221, the mirror of the electrolyte is covered with light floating "winged" balls. The balls are made of the material resistant to the electrolyte. The wings fully cover the mirror of the electrolyte, but they go apart when new parts are being put into the solution and then come together over it again and cover the electrolyte thus preventing evaporation.*) [32]

**Task 40:** Let us assume that a play has only negative characters but besides their actions the author would like to express some of his own ideas, positive ideas. Only one of the characters can deliver these ideas. Yet it would not seem natural if a negative character spoke of positive things.

Is there a way to deliver positive thoughts without putting at risk the true nature of the character?

(*Again the contradiction is eliminated by distribution in time. In the play by Alexander Ostrovsky "Lucrative Position" the main character looks impeccably credible at first and delivers a positive monologue. Yet it turns out that he is a swindler and his positive speech is just an element of his fraud*.) [28]

# Ideality

*Every contradiction has a number of solutions.*
*This chapter is devoted to the ability of finding the best solution.*

## Disappearing Systems

If two systems carry out the same function but one of the systems is twice as large as the other, which one is better? Obviously, the smaller one is. And if one of the systems is twice as heavy? Then the lighter one is. Twice as expensive? Then the cheaper one is. It would be perfect to have an operating system which does not require any space, is weightless and costless.

TRIZ has a concept of an **ideal system**:

**An ideal system** is the one that does not exist but its **functions are performed anyway**.

**Example 66:** In ancient Greece theatres had no decorations in our current understanding of the word. But how did they explain the setting of the play to its viewers? One of the solutions they employed was "a theatrical slave". This person went to the busiest places of the city (e.g. a market or a square) and explained that there was going to be a performance which would be set up, let us say, on the bank of the river by the forest.

In the Middle Ages cities grew larger, and the spectators did not come together in the same market place or a square. Therefore a special actor (he was called the Prologue) appeared on the stage before the play started and told the spectators that the action of the play would take place on the bank of the river by the forest.

In the early modern period life started gaining pace, and the Prologue made performances significantly longer. Therefore actors themselves described the setting of the play in their monologues. A character would not just say: “I will kill you!” Instead he or she declared: “Here, on the bank of the river by the forest, I will kill you!”

In contemporary life the old method still slowed down the run of the play. So people invented decorations, which made explanation of the setting redundant. Spectators could see the river and the forest with their own eyes.

**Example 67:** The substance extracted from the oil well is not pure oil as it contains water and associated gases. Immediately after extraction crude oil is separated from water and gases and pumped over to the customer. However, oil is a viscous substance, and pipeline transportation for thousands of kilometres requires many pump stations consuming lots of electricity, which increases the price of the oil. If only oil were less viscous…

At first scientists tried to grow bacteria which would consume oil, and their metabolic products would dilute oil. The research took a few years but the results were not good enough. Then a new solution was found: crude oil was not separated from water and gasses immediately after extraction. “Gaseous” oil was much less viscous, it was easier to pump and transport. Oil refining was performed at the destination. [32]

What do these examples have in common? At first, the solution involves an extraneous system – a slave who is not related to the play or bacteria not related to the oil. The next step is introduction of elements that are close to the system (the Prologue – an actor from the same theatre). But eventually elements within the system itself (actors of the play, gases in oil) provide the solution. Finally, the last step – the new system disappears altogether but its function remains. So explanation of the setting disappeared but spectators understood everything perfectly.

This tendency proved to be so regular that G.S. Altschuller formulated it as one of the laws of development of systems: **systems perfect their form in the process of development.**

One of the elements of talented thinking is the ability of one`s mind to omit transitional phases of the system development and form ideal or almost ideal models immediately. For example, the inventors could have thought of the gases in crude oil at once instead of bothering with bacteria. Ancient Greeks had a number of theatrical devices called machines, and again there were no objective obstacles that would not allow creating proper decorations. After all, they already knew painting at that time.

This aid is written in a computer which incorporates many ideal systems such as a pen, a pencil, an eraser, a corrector, a brush and colours, a library, a file index and dozens or even hundreds of other systems. Computers have also evolved from machines occupying entire halls into small flat boxes.

## In Quest for Ideal Systems

If the system is ideal (meaning, it does not exist), then its function is performed by other systems that still exist. Actual things that can be used to execute functions are called **resources**.

There are a number of stages in the process of system perfection. We have already seen that the process starts with application of **external resources** not related to the initial system.

**Example 68:** The art of the late medieval period was dominated by a specific kind of “symbolism”. Writers created various comparisons that only they could understand. A so-called “gloss”, i.e. an explanatory note deciphering these comparisons was placed at the end of the novel. The same phenomenon prevailed in painting; for instance, the portrait of Catherine II painted by Dmitry Levitsky included an eagle sitting at the empress`s feet. The bird had no relation to Catherine II whatsoever but was a popular symbol of power at that time. [55]

**Example 69:** One of the first locomotives moved… on its legs. It also had wheels but its motion was provided by a pair of mechanical steam powered legs installed in the rear of the engine. The levers pushed off from the ground and pushed the locomotive forward. This “walking miracle” moved on for several dozen metres before its boiler exploded. [63]

**Example 70:** A renowned mystical theologian Richard, a prior of Saint Victor`s cloister, explained tidal motion as breathing of a huge underwater monster. [69]

Explanation of tidal motion as breathing of a monster (where did it come from?), an eagle at the feet of the empress (there were no eagles at the court), legs for a steam engine (what other devices had legs?) – all these are exterior elements not connected with the original system. They only add a certain effect (e.g. the power of the empress is confirmed, the steam engine moved for several dozen metres) which is not stable or long-lasting. Still, this method has been popular up to now. The Tunguska catastrophe was explained by explosion of a nuclear-powered alien ship; redshift of galaxy clusters is explained by some kind of invisible "dark energy".

However, the law of increasing ideality is inexorable. Sooner or later strange elements are discarded, and a next stage of development sets in. **Elements of the closest supersystems or those from the surrounding environment** are drawn into the process.

**Example 71:** Gothic temples were supposed to have sculptures**.** Figures were not separated from the walls yet, and there had to be many figures. Sculptures covered the walls, surrounded the columns, ascended to "the first floor" – into niches in the walls and columns. There was no empty space whatsoever, but it was imperative to add more figures.

They started placing sculptures outside temples – on their facades. [4]

**Example 72:** Aircraft landing speed is around 200 km/h. At this speed, chassis strike against the runway extremely hard, which results in heavy tyre wear after only a few landings. It would be possible to avoid the hard impact if the wheels spin reached the speed of landing before the aircraft touched the runway. One of the solutions was to equip the wheels with small motors but it increased the weight of the plane and air resistance.

The problem was solved in a very simple way. The wheels were equipped with small slanting spades on each side, and now they were spun by the head airflow. [97]

The facade of the temple is one of the elements of its closest supersystem; so space for new sculptures required no extra expenses or new architectural inventions.

Likewise, the wheel of an aircraft was spun by the air which is an ever-present element of the surrounding environment and is absolutely free.

However, the resources that are part of the system are considered to be the most perfect. They are called **intra-system resources**.

**Example 73:** Soviet sculptor Vera Mukhina intended to create a modest sculpture she called “The Wind”. It was supposed to present a woman fighting a heavy wind gust. The only way to show the ultimate effort was to depict the character’s muscle tension, which would only be possible if the figure was naked. The problem was that the character chosen for the sculpture was a peasant woman, and a naked peasant woman would not look natural.

Mukhina divided the sculpture into two parts. Its lower part was wearing a traditional skirt, but the upper part was naked, which enabled the author to show muscle tension. [99]

**Here, part of the original system** was used to express the desired meaning.

**Example 74:** Agricultural irrigation system is a huge network of water pipes. It starts at the pumping station and carries water to the fields. Each pipeline in the net ends with a water splashing nozzle that is steerable. Water consumption can be regulated if consumption of water at every particular nozzle is known. Nozzles are equipped with water expenditure gauges that send signals to the operations control stations which steer nozzles. But if a wire is pulled from each nozzle to the control station, it would become very expensive, complicated and unreliable.

The solution was simple. Water is a very good electricity conductor, and this quality was used to transmit electric signals to distant control devices.

Again **an intra-system element** was used to solve the problem.

Everything that is essential for solving a problem can be found within or near the system. To facilitate identification the resources can be divided into a few most common types:

- space resources
- time resources
- object resources
- action resources
- information resources.

If it is necessary to find a place for a new object in the system but there is lack of space, space resources are needed. Consider the example of gothic temples. There was no space inside, so architects found it outside.

If it is necessary to add a new stage to the continuous process, time resources are needed. Consider the example of Blackmore's guitar: when he needed to change the guitars, he found a small pause at the end of the show.

If there is no tool to perform the necessary action, object resources are necessary. This solution was found when there appeared a necessity to send water consumption signals. The signal was transmitted by the water itself.

If there are the desired objects but they fail to act in a necessary way, action resources have to be found. Let us go back to the example of the Brownian motion. Scientists had to discover a force that pushed grains of pollen in the water. Einstein found it in the properties of water itself – grains of pollen were pushed by moving molecules.

And finally, if there is not enough information about important processes or objects, information resources are necessary. More precisely, these are object resources that carry information.

**Example 75:** The Byzantine Empire was officially ruled by two people: the Emperor and Jesus Christ. The throne also had a double seat. Half of the throne was taken by the emperor. How to make it clear that the other half was occupied by Christ? The necessary information was provided by the cross that was placed on the other part of the throne. [16]

So, if there is a problem, there must be proper understanding what resources are needed for solving it. The next task is finding these resources (looking for them, first of all, within the system).

**Example 76:** By the end of the 19$^{th}$ century natural philosophers had come to a conclusion that all the possible kinds of energy had been discovered: mechanical, thermal, chemical, electromagnetic. All these kinds of energy manifest themselves as interaction of objects.

Is it possible to predict further development of energy physics?

To be able to solve tasks that require prognostication, one must have a clear idea of what resources are necessary and where the available resources come from. In this case, there is a need for resources for interaction of objects – the resources of energy. All the resources that were known at the end of the 19$^{th}$ century were external. So, the task was to find resources within the bodies.

In 1905 Albert Einstein developed the famous formula of the inner energy of bodies – $E = mc^2$. This laid the foundations for research and application of nuclear energy. [15]

**Example 77:** An independent genetic scientist wanted to investigate λ phage in his private laboratory. The virus discovered in 1950s can reside within the genome of its host not manifesting itself for a very long time, but once the host cell experiences stress (starvation, poisoning, etc.), the λ phage destroys its DNA and reorganises the cells to create replicas of λ phages.

The scientist wrote a letter to the laboratory that was studying λ phages with the request to send him a sample culture of the virus. However, the laboratory did not take the request seriously and declined it.

How did the scientist get a sample of λ- phage?

Again, let us consider this problem in terms of resources. We need the resource of the object – at least a few molecules of λ- phage. The scientist made an attempt to receive the molecules from an exterior source – the laboratory; as he did not succeed, he tried to look for another, more ideal intra-systemic source.

The scientist realised that λ- phage was just a molecule and could have been dispersed all around the laboratory; subsequently, the letter from the laboratory could also carry some molecules of λ- phage on it. He placed the paper into a nutrient solution and grew a culture of the necessary virus very quickly. [3]

**Example 78:** A doctor Sydney Ringer of the University College Hospital, London, at his spare time was practicing pharmacology and for many years worked with isolated frogs' hearts. He noticed that the organs suspended in a solution of sodium chloride continued to contract for half an hour after they were isolated form the body. Once an isolated heart exceeded this period of time, it seemed that it could go on beating for an indefinitely long time.

Ringer made a suggestion that there had to be some particular substance that supported heart contraction. Yet, the experiments were always conducted with caution. Extra-system substances could not have gotten into the experiment.

What was the explanation for the given effect?

One has to look for the resource of the object, the substance that can support cardiac contraction. There were no extraneous sources for such substances in the laboratory.

Moreover, any substances from the super-system were also excluded by the conditions of the experiment. So there was some intra-system source. A solution of sodium chloride consists of water and boiled salt. The salt used for the solution was specially purified, so the answer must have been in the water.

Ringer sent an enquiry about the ions in the tap water to the company responsible for the water supply in northern London. They answered that there was high concentration of calcium ions in the water. Experiments conducted by Ringer proved that calcium was the substance which facilitated cardiac contraction of isolated frog hearts.

## Tasks for Finding Resources

**Task 41:** In Medieval Chinese temples it was forbidden to place sculptures, paintings or any other decorative elements. There were only bare white walls. But people in the East were used to temples where they could enjoy beauty and meditate.

How could they ensure this possibility without violating their religious canon?

*(Here we need **resources of objects** – beautiful objects. Since there are no objects inside the temples, they have to look for such objects **in the external environment**. The solution is to use the surrounding nature. Chinese temples were built so that their windows looked across beautiful landscapes.)* [59]

**Task 42:** Until the end of the 19th century electromagnetic waves were considered to be aether waves, but experiments with light deflection proved that the amount of aether was greater than there could be among the molecules of the studied substances.

Where does this supplementary aether come from?

(*Scientists needed **space** resources where they could "put" the additional aether. H.A. Lorenz proposed that atoms and molecules contain this aether –* an ***intra-systemic resource***.) [60]

**Task 43:** A DNA molecule contains not only fragments that carry genetic information but also "empty" fragments. When RNA replica is created, it also contains "empty" fragments. Afterwards the RNA replica moves to another section of the cell where it becomes a base for synthesising proteins. In this case, proteins should also have unnecessary fragments. Yet these fragments were not discovered.

What is the explanation?

(We need ***time*** *resources when the RNA replica can get rid of the "empty" fragments. At the beginning of 1980s it was discovered that they do it on their way from the DNA to the place where they synthesise proteins –* ***an intra-systemic resource****.*) [57]

**Task 44:** The majority of the Solar System formation theories have it that it emerged from a protoplanetary gas cloud. However, in this case concentration of noble gases in the atmosphere of the Earth should be the same as in the atmosphere of the Sun. In fact, the atmosphere of the Sun contains billions times more gases than the atmosphere of the Earth, which at its early stages had no atmosphere whatsoever.

What is the explanation for existence and composition of the atmosphere of the Earth?

(*Two types of resources are required:* ***objects*** *that could form the atmosphere, and an* ***action*** *that would result in formation of the atmosphere. Objects are minerals of the Earth. The action that could decompose minerals is already known – volcanism. According to the current conceptions, gases of the atmosphere of the Earth appeared as a result of volcanic eruptions.* ***Both resources are intra-systemic****.*) [29]

**Task 45:** Primates often consume meat and even hunt other animals. Meat constitutes an indispensable source of protein, but raw meat is very difficult to chew. Scientists have calculated that time spent by apes on chewing meat can vary from a couple of hours to a whole day.

How can apes facilitate and accelerate the chewing process?

(*They need* ***an object*** *that can help to make meat tender.* ***An exterior resource*** *– stones. Apes often place meat on a stone and chop it with another stone or a thick stick.* ***A super-system resource*** *– hard leaves. Some apes put such leaves into their mouths and chew them alongside with a piece of meat. Leaves help to grind meat.*) [78]

**Task 46:** To be able to study the distant past of the Earth, scientists have to be able to study the early atmosphere. But it is long since gone because composition of the atmosphere changes rapidly.

How can scientists study the air composition of the early historical periods?

(*They need resources of the* ***objects*** *which contain air from the early historical periods.* ***A super-system resource*** *that has been preserved is ice in the northern glaciers and the Antarctica. Scientists drill holes in these glaciers and collect ice samples at various depths. The ice contains air bubbles from different periods of time*.) [64]

**Task 47:** In the 8th century BC ancient Greeks founded a wealthy city of Sybaris in the territory of modern Italy. Inhabitants of the city enjoyed making various festivals. To make them still more beautiful, they taught their horses to dance to music.

Sybaris was at war with neighbouring Kroton, a poor city whose cavalry was not as numerous and strong as that of Sybaris.

Is there a way for Kroton to defeat the cavalry of Sybaris?

(*They needed to find* ***action resources*** *that would not let Sybaris' cavalry fight and thus detain military action. The resource was found in* ***the super-system****. When the cavalry of Sybaris went out of the city walls, Kroton's soldiers started playing musical instruments. Instead of attacking, the enemy`s horses started dancing*.) [10]

**Task 48:** While studying falling bodies, the ancient Greek philosopher Aristotle came to the conclusion that falling velocity depends on the weight of the falling object, e.g. a heavy stone falls faster than a light feather.

Galileo Galilei verified Aristotle's findings. He threw various objects from a particular height and monitored their falling velocity. His findings showed that the falling velocity of the majority of bodies did not depend on their weight. Still, the falling velocity of feathers and small pieces of cloth was lower. Provided that Galilei was right, how could such exceptions be explained?

(*Two types of resources are required:* ***action resources*** *– slowing down light objects fall, and* ***resources*** *of* ***objects*** *– something that will slow down the fall. In this case this object can be found in* ***the super-system*** *– it is the air, which cannot resist the fall of heavy objects but can slow down light objects. This was exactly the explanation given by Galilei*.) [44]

Thus, we have examined two of the basic properties of talented thinking. These are the very procedures of thinking that allow solving problems and creating new adequate concepts.

However, these abilities cannot fully develop and unfold unless we ensure simultaneous development of supplementary abilities. Let us consider two of them.

# Language for Talented Thinking

*The purpose of this chapter is to teach people to use all language resources and to see not only the existing things but their potential as well.*

An ordinary ungifted person can only imagine something that already exists. A talented person can easily imagine something that does not exist yet. Their fantasies may differ greatly from the existing things.

Human thinking is limited by the language, but the possibilities of the language are not used in full.

## Words and Actions

Human thinking is inseparable from the speech, from the language. No thinking – no language. No language – no thinking. New-born babies do not think but perceive and react; real human thinking develops alongside with language acquisition.

However, the tight connection between a concept and a word has its negative sides.

**Example 79:** A young girl was murdered under mysterious circumstances in the suburbs of London. According to her sister, the girl`s last words were, “The speckled band!” The case would have remained unsolved if not for Sherlock Holmes. He noticed that one of the meanings of the word *band* in the English language was a “ribbon”. This seemingly insignificant fact allowed him to solve the crime where the instrument was a rare parti-coloured snake.

Scotland Yard detectives took into account only one meaning of the word *band* – a group of people, which did not allow them to see any other versions of the event.

When humans learn to speak, they denominate objects with words. Then the word designates the object. Humans judge the objects by their names.

On the other hand, discovery or invention in any sphere of human activity means going beyond the limits of habitual conceptualisation, in other words, beyond the limits of meaning determined by the word.

**Example 80:** During one of my workshops I asked a question: is it possible to freeze a liquid with hot water steam? The answer was – no. The audience immediately associated the word *freeze* with sub-zero temperature on Celsius Scale. However, if we speak of liquid steel, it will get frozen by hot water steam faster than water turns into ice in a home fridge.

This is of crucial significance for talented thinking. Talented thinking is about overcoming the meanings imposed by words.

Educational systems around the world are based on the same principle. Human beings learn about objects through demonstration and description of objects labelled with terms-names. Then generalisations and conceptions of these objects and phenomena are explained. More terms are introduced. Then students are taught to see these generalisations in other similar situations. In the end, the term substitutes for reality and for ability to see something else in the things.

It will not occur to such a human to think over the real nature of the term and of the mechanism of the phenomenon. The phenomenon is explained by the term.

We may ask any man a question: why apples fall to the ground? The answer will be: because of the gravity. But what is gravity? Why does it pull apples to the ground and does not let them go up? Such questions do not usually come to mind.

Many truly innovative researches and even entire branches of science have emerged from coining terms.

**Example 81:** When Johannes Kepler realised that planets moved in elliptical orbits, he tried to find an explanation. Kepler could think of only one model which could explain that – planets moved uniformly but some kind of force made them deflect from the direct line.

The suggestion immediately triggered two questions: why has there to be a force that deflects the planets from the direct line, and what kind of force is it? To answer the second question, Kepler proposed that the Sun pulled on the planets, and he even put forward the gravity formula. In order to answer the first question, Kepler suggested that there existed another force, the force that kept bodies in linear motion. Before studying that force the scientist named it *inertia*. [44]

**Example 82:** In 1927 a famous Russian writer and art historian Yuri Tynyanov published an article "On Evolution in Literature" and was the first to express the idea about regular development of literature irrespective of the writers' will. The article introduced new terms such as *literary system*, *system of functions* or *literary sequence*. Still, the research that he described in his article was yet to be done. [82]

**Example 83:** In 1832 Michael Faraday began studying a previously unexplored phenomenon – electrochemical decomposition of solutions. The first thing he did was changing the entire terminology of electrochemical phenomena that had been created under the influence of the previous ideas and was highly misleading. Faraday substituted the name *poles* by the name *electrodes* because the term *poles* was associated with the magnetic adhesion force, which was not present in electrochemical decomposition. Then he called the positive electrode *anode* and the negative one *cathode*. The substance that produced an electrically conducting solution was called *electrolyte and* the very act of dissolving was called *electrolysis*. All these words over time became scientific terms. Using the new terminology, Faraday discovered the basic laws of electrolysis. [50]

## "Construction Kit for New Terms"

Usually new terms are created to show:

- the function of a new object or phenomenon

**Example 84:** Substances that are designed to reduce the damage caused by radiation are called radioprotectors from Latin *radius*, meaning "ray", and *protector*, meaning "defender".

**Example 85:** There is a method of separating various constituents of organic mixtures by pigmenting them into various colours through their interaction with some chemicals. The inventor of the method, an Italian-born Russian scientist Mikhail Tsvet, called it chromatography from the Greek *chroma*, meaning "colour", and *graphein*, meaning "to write". [58]

- the structure, composition of an object or phenomenon

**Example 86:** Antoine de Lavoisier together with his colleagues developed a nomenclature of chemical substances that allowed determining their composition by their names. For instance, calcium oxide is made of calcium and oxygen (Lat. *oxygenum*), sodium chloride is made of sodium and chloride, etc. [47]

**Example 87:** Names of polyhedrons were coined from the Greek words denoting a particular number and the word *hedros* meaning “face”. Consider the following examples: tetrahedron (*tetra* – four), octahedron (*octa* – eight) or dodecahedron (*dodeca* – twelve).

- peculiarities (external or internal), characteristics of an object or phenomenon

**Example 88:** It has already been mentioned that Faraday created many new terms to be used in electrochemistry. The term *electricity* comes from the ancient Greek *electron,* which means *amber.* The word *electrode* is composed of *electron* and *odos,* meaning “way”.

**Example 89:** In 1912, during preparations for filming “Cabiria”, Italian film producer Giovanni Pastrone patented a cart for moving the camera. He called this method of filming *travelling*, from the English word related to motion or changing place. [83]

- the origins of an object or phenomenon

**Example 90:** Artificial objects or phenomena are often called *anthropogenic.* This term was coined from the Greek words *anthropos* – “man” and *genos* – “kin, stock”. And the meaning of anthropogenic is “originating from a human”.

**Example 91:** A prolific meteor shower that radiates from the constellation of Leo (from the Greek *leon*) is called *Leonides* (*eidos* – “descendant”).

There is one more type of terms that one might call “irrelevant”.

**Example 92:** The structure of mythological temporalism is interesting because it includes both extemporality of the sacral existence and atemporality of the reality. According to this world outlook, separate parts of the reality are not separated by different modes of time and thus need not be prognosticated. [98]

In simple words, it can be related as follows:

“The structure of mythological concepts of time is interesting because it includes both afterlife, which is timeless, and real life, that seems to have no time whatsoever. Real life events do not have different timing, and despite being sequential in time they are perceived as if they were simultaneous. If this is true, then there is no point in prognosticating them because changes are not to come anyway”.

If a decision is made to create a new term, there is a multitude of resources to do this. It can be “constructed”:

- using ancient languages

**Example 93:** The word *azote* (modern nitrogen) was coined from two Greek words: *a* – a negative prefix, and *zoi* – “life”. Scientists who discovered azote experimented on mice. They put them into azote, and the animals died instantly. Today it is well-known that nitrogen is not dangerous for organisms, and the mice died because of lack of oxygen. However, at the time of the discovery the name of the element that implied “defying, killing life” seemed justified.

**Example 94:** The word *literature* stems from the Latin word *littera* – “letter”. Thus, literature is something depicted in letters.

- using modern languages

**Example 95:** The Russian word *суржик* at first denominated a mixture of different grains, e.g. wheat and rye. Later, the term came to denominate mixed languages, mostly the Russian-Ukrainian dialect. Today this word is a common linguistic term (its English variant – *surzhyk*, French – *sourjyk*, Italian – *suržik*, etc.). Recently, the term has been used to describe mixtures of the Ukrainian language with more distant languages, e.g. to name the dialect used by the Canadian Ukrainians.

**Example 96:** During his expedition to Alaska American palaeontologist Neil Shubin and his colleagues discovered fossils of an animal that could have been a representative of the evolutionary transition from fish to amphibians. Since the excavation was conducted on the territory of the Eskimos, Shubin asked their elders to help in naming the animal. Today palaeontologists know it as *tiktaalik*, which means “huge fresh-water fish”.

- by means of abbreviation

**Example 97:** The term *laser* originated as an acronym for *“**l**ight **a**mplification by **s**timulated **e**mission of **r**adiation*”. A device that allows creating thermonuclear fusion in laboratory settings is called tokamak (*токамак*) – from the Russian *тороидальная*

***ка**мера с **ма**гнитными **ка**тушками* meaning “toroidal chamber with magnetic coils”.

**Example 98:** A common Russian word for a tramp “*бомж”* is an abbreviation of records from the police protocols – ***б**ез **о**пределенного **м**еста **ж**ительства* (without a fixed place of residence). Today this word functions in a number of other languages as well.

- using mythology

**Example 99:** In 1735 Swedish chemist George Brandt was studying a bluish mineral that resembled copper ore. Despite general similarity, he did not succeed in extracting copper through usual processing. Miners believed that this ore was bewitched by Kobolds – ancient underground spirits. In 1742 - 1744 Brandt managed to prove that the blue mineral contained not copper but an entirely different metal with chemical characteristics similar to those of iron. The metal was named after the mysterious underground spirits – cobalt.

**Example 100:** Planets of the Solar System and some of their natural satellites were named after antique gods and demigods. Planets: Mercury, Jupiter, Mars; satellites: Iapetus, Titan, Nemesis…

- using geography

**Example 101:** Particular periods of primordial history are named after places where scientists found certain artefacts. *The Aurignacian period* took its name from the cave in the south-west of France, *the Mousterian period* was named after the cave of Le Moustier, but *the Perigord period* was named after Perigord Plato.

**Example 102:** A number of chemical elements bear names of countries or places. *Polonium* was named as a tribute to Poland, *ruthenium* came from the Latin name of Russia – *Ruthenia*, *scandium* was named after Scandinavia, and the name *lutetium* was derived from the ancient Roman name for Paris – *Lutetia*, etc.

- from names and surnames

**Example 103:** In 1898 Vladimir Amalitsky discovered an ancient reptile and named it after the renowned Russian geologist Alexander Inostrantsev – *inostrancevia*.

**Example 104:** A whole range of physical quantities and phenomena were named after famous physicists. The unit of electric tension is called *volt* after Alessandro Volta.

The unit of electric current is named after André-Marie Ampère – *ampere*. The surname of Italian scientist Luigi Galvani is used in many phenomena and devices – device *galvanometer*, process *galvanisation*, technology G*alvano-plastics*, etc. The unit of force in the SI system is called *newton*, and the unit of measurement of exposure to X-rays and gamma rays is called *roentgen*.

This way of constructing new terms is common to other branches of science as well. Such chemical elements as *mendelevium* and *curium* were named after scientists. Henri Poincare discovered a new type of mathematical functions and called them *Fuchsian functions* after the outstanding mathematician Lazarus Fuchs. New asteroids, which are discovered almost every month, also bear well-known names or surnames - *Alferov, Beatles, Cabot, Diderot, Fellini, Lem, Vladvysotskij* and thousands of others.

In general, terms can be formed of any other words as well.

**Example 105:** Names of noble gases stem from ordinary Greek words: neon (*neo* – new), argon (*argos* – idle, inactive), krypton (*crypt* - secret, hidden), xenon (*xenos* – stranger). Radon, another noble gas, at first was considered to be emanation of radium, and so was named after it.

You should find and read books by Stanisław Lem, a wonderful science fiction writer, “The Star Diaries” and “Fables for Robots”. They are genuine manuals of word formation. Witty, unusual and funny words fill the pages of these books. Besides, they make excellent parodies of many phenomena in our life, including scientism. Outstanding examples of word formation are also books by Lewis Carroll and poems by Siemion Kirsanov.

## Tasks for Inventing New Terms

**Task 49:** Invent a new insect that you have supposedly found in the Amazon rainforest (or in Greenland glaciers); describe its appearance, habits and nutrition. Propose a few dozen names for the insect in question. Use peculiarities of its appearance or nutrition, its habitat, names of renowned people or your acquaintances (you might as well use your own name), etc. You may organise a contest quiz for your friends to find out who will come up with the highest number of names or the most original name.

**Task 50:** If you discovered a new element, new planet or new phenomenon in physics, which famous name would you give to it? What would these names be like?

**Task 51:** Find the words that were used to create the following terms:

- The *Magdalenian* period
- Chemical elements *selenium* and *tellurium*
- Prehistoric reptiles *brontosaurus, ichthyosaurus, pterodactyl*
- Metrical foot in poetry *iambus, choree, anapaest*
- Unit of electrocapacity *farad*
- Unit of energy *calorie*
- Name of the sacred Christian writings *Evangelium* (*gospel*)
- Name of asteroid *Berry*
- Name of the *Kartvelian* languages
- Name of flower *Victoria Regia*

Sources necessary for accomplishing this task are available on the Internet.

**Task 52:** Take any foreign language dictionary. Pick out any word and use it to form a few terms. What objects or phenomena could bear these names? If there are no such objects, just invent them. Perhaps these objects already exist but have not been discovered yet.

**Task 53:** Choose any word of your mother tongue (it might even be a slang word) and try to form a term which could be used in other languages. My students, for example, came up with a brilliant “economic” term – *халявинг* (*freebing*).

**Task 54:** Develop a habit of trying to find the source of any term that you come across.

## Why Languages are Necessary

The ability to invent necessary words is just part of a more general ability. A new term provides a possibility to consider an object or phenomenon from a new perspective. But the possibility to understand **the whole** world is granted by languages.

But how do we use languages? Not just foreign languages but our mother tongues as well. Unfortunately, our everyday speech is very poor. The language in general is a huge and complicated system. We use a negligent part of this system, which is widely recognized as “the correct language application”.

Languages belong to people who speak them. Unfortunately, constant attempts are made to tear out this faculty from the people by imposing artificial standards of “literary language”, reproaching and reprimanding. Sometimes linguistic norms are imposed by legal means.

According to the legend, there is a tribe living on the banks of the Amazon River. Every morning their shaman performs a complicated ritual of dancing and chanting on the bank of the river. The tribe believes that if shamans stop doing this, the Amazon River will stop flowing.

This is just the kind of ritual dances and incantations that many linguists perform. They are truly convinced of the strong necessity of imposing “linguistic norms” which will prevent their language from dying and the people from perishing in catastrophes. Their slogans are well known: “the language is the soul of the nation”, “the language has come to us through centuries”, “the language is our wealth and must be treated with care”, etc. Regrettably, many people believe them.

Fortunately, the role of these “guardians” in the life of languages is similar to the role of the shaman on the banks of the Amazon River. The language develops according to its own laws; it does not care who dances and chants on its banks.

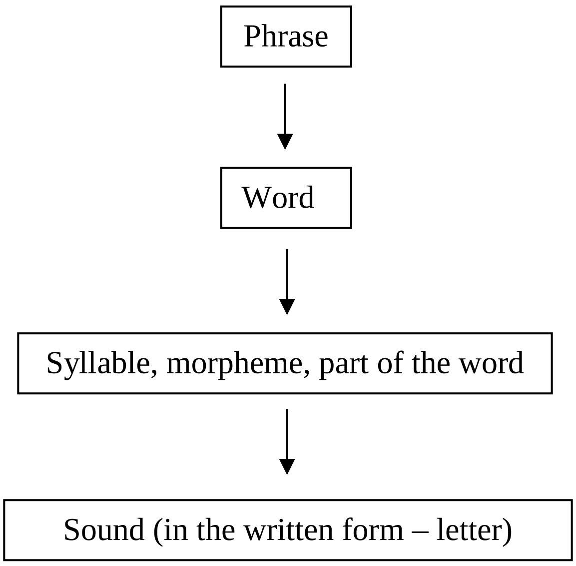
How does a little one perceive the world? It has already been mentioned – through the language. If babies learn the language from their parents, books and teachers and acquire the language which is “correct”, unchangeable and intolerable to any deviations from the imposed norms and regulations, these little human beings will perceive a fossilized world, the world which scares them with abundance of unknown, meaningless restraints artificially declared as “correct”.

To develop a child as a creative personality, to ensure that he or she becomes truly talented, a child must hear a natural and freely changing language, a language that reflects the incredibly broad and dynamic world.

Where can we find such a language? It is all around us! One just has to step out of the cage built by the language purists.

## Principles of Incorrect Speech

Unexpected new words and meanings can be acquired not only by going through words with a fine comb. Methods of creating new phenomena in the language are as systemic as the language as a whole. Let us consider a simple hierarchy of a language:




Any transformation that comes to your mind can be made at every level of the language. Let us begin with the rank of **sounds (letters).**

- Sounds can be substituted for other ones in order to get an unexpected meaning or association.

**Example 106:** Re**b**rigerator (re**f**rigerator), **d**oshbasin (**w**ashbasin), **m**ental machine (**d**ental machine), **f**igwam (**w**igwam). “A “Scottish” wish *seven feet beneath the k**il**t!”* is a joke coined by changing letters in the traditional well-known marine farewell

"Seven feet beneath the keel!" As a result *keel* was changed into *kilt* – a traditional dress of men in the Scottish Highlands.

- In order to achieve a new meaning, new association, we can insert supplementary sounds.

**Example 107:** Privat**se**ization (privatisation), sup**f**erior (superior), pres**t**erved food (preserved food). What kind of car does Jesus drive? A Chris**t**ler.

- A new meaning, new associations can also be achieved by exchanging sounds.

**Example 108:** Si**lk**y – si**kl**y, f**ur**naceman – f**un**raceman.

Various transformations can be made at the level of **syllables, morphemes and parts of words**:

- A word can be divided into parts, each carrying its own meaning, and these parts can be slightly changed so that they remain recognizable.

**Example 109:** Moustache – Must ache! Disgracefully – Dis Grace fully! Hellbent – Hell bent. She passed along the catwalk, as if she were walking a cat.

- One word can be substituted for another.

**Example 110:** Fourgon, five gone. Begone, beg two…

- You can rearrange parts of the word.

**Example 111:** "Some drink Gunfire, others fire like a gun". Horseradish – radish horse. Engorge – gorgen.

- Interesting results can be achieved by using morphemes (suffixes, prefixes or endings) in a formally correct way but without traditional restraints.

**Example 112:** Puddle – puddly (addle – addly). Embroidery – to embroider (archery – to archer). To type - typist (to hype – hypist). Trousers – a trouser.

- A morpheme can be substituted by another morpheme often with the opposite meaning, even though traditionally it is not accepted.

**Example 113: En**compass – **dis**compass. **In**cavation – **out**cavation. **F**ull service – **sk**ull service.

- One word or several parts of a word can be presented as clippings of other words.

**Example 114:** Portabella – **porta**ble **Bella**. Love me – **lo**ng **ve**sted **me**asles.

- One of the parts of a word may be treated as a separate word and substituted by another word.

**Example 115:** **Trans**formation – **trucks**formation. **Right**eous - **left**eous. **Boiler**maker **–** **oiler**maker. Short-**sight**edness – short-**legg**edness.

There are plenty of resources for achieving unusual results at **the level of words.**

- Interesting effect can be achieved by using homonyms – words that share the same pronunciation but have different meanings.

**Example 116:** Dragon**flies**? No, dragon **sits**.

- We can use phonetic associations with widely used words.
- We can use phonetic associations based on widely used words.

**Example 117:** Are you gay? No. I have a wife.

- Words can be put together to achieve unusual and interesting combinations.

**Example 118:** Handwaffing and twitchlegging. A city – Thatisthere. Teethclappers, creepskinned, haircurled. A famous Russian device *лохотрон* (could be rendered into English as *chumptron* – originally a lottery machine used by street defrauders at the beginning of 1990s.).

- Parts of clipped words can be joined.

**Example 119:** Chymelon, grapear tree, the Dreamazon River, Tomatokyo.

At **the level of phrases** we come across a lot of interesting things**.**

- Different set expressions can be joined into unusual combinations.

**Example 120:** “Don’t be silent like a fish that is trying to keep its head above the water”. “Calm your mouth!” “Listen here!”

- You can simply substitute words in well-known quotations or phrases.

**Example 121:** If we change one word in the popular quotation from Pushkin’s “Capitan’s Daughter”, “God save us from seeing a Russian revolt, senseless and merciless”, we will get a witty and topical expression: “God save us from seeing Russian **service**, senseless and merciless”.

These are just a few of the possible methods. The deep waters of the subject have not been studied yet. Each of us can try to do it.

The considered examples help to realize how rich any language is versus the miserable cuttings presented to us as “the correct literary language”.

For children, the language is their first aid in talented thinking. So, speaking to children try to use as much play-on-words as possible. Read to them “Alice in Wonderland”: it is a real manual of free language. Encourage your children to read or to listen to poems by Semyon Kirsanov – the greatest experimentalist in Russian poetry. Extend these wordplays from books to your daily communication with children. Stimulate them to invent new, “incorrect” words and phrases.

When we scold “retrogrades”, “reactionaries” and “bureaucrats”, we fail to realize that from their early childhood these people were taught to stick to “the Correct Answer”. They do not wish anybody ill, they just fear to step away from the rules, norms and traditions. It seems to make their life easier and safer.

It all starts with “the correct language”. Then it is supplemented by “the correct behaviour”. Teachers expect “correct” answers. Supervisors give “correct” orders. In the end, we reap what we sowed so industriously. And we still wonder where it all comes from. And as usual, we start looking for snakes in the grass.

## Tasks on Invention of Words

**Task 55:** Give a few examples for each type of transformation.

**Task 56:** On completion, you will have many interesting words. Try to compose a short story from these words.

**Task 57:** Try to do the opposite: write a short story using standard language and play with its words.

**Task 58:** Take any dictionary and try to change the words one by one using transformation techniques. Put down the number of words you were able to transform in ten minutes. Do this every day, and you will see your observation skills develop. You will quickly learn to see the unexpected and unbelievable possibilities of almost every word.

**Task 59:** Take any work of classic literature and pick out any successive couple of phrases. Try to rearrange parts of the phrases. Put down the most interesting results.

# Technology of Creative Activities

*This chapter is devoted to card files of information on creative activities: how these files are made and handled, how to draw the right conclusions.*

*Real* creative work is impossible without processing huge amounts of information. This is an extremely complicated and demanding process. One has to get used to this work and help future Creative Personalities get used to it as well.

## Salvatory Card Index

Sometimes a single fact can trigger a new hypothesis, a new model or a new concept.

**Example 122:** In his conversation with Humphry Davy natural scientist Hans Ørsted mentioned an interesting observation: he noticed that if electric current was flowing through a wire, a magnetic needle placed beside it deflected either towards the wire or away from it. Faraday, who heard this conversation, proposed immediately that the needle did not deflect to or from the wire but around it. This idea developed into the entire theory of electromagnetism, and today all electric generators are based on this model. [48]

But a hypothesis is not a model yet. In order to develop a theory or at least a coherent concept, its variants, peculiarities and consequences must be studied. This requires hundreds, thousands of facts: results of experiments, data from other researchers, observations, etc.

**Example 123:** Carl Linnaeus examined and described about ten thousand plants and four thousand animals to build his taxonomy. His private collection included nineteen thousand herbaria leaves, more than three thousand specimen of insects, more than one and a half thousand shells, more than seven hundred samples of corals and two and a half thousand samples of minerals.

**Example 124:** In 1572 Tycho Brahe noticed a bright star in the constellation of Cassiopeia which had not been observed before. For 17 months he watched this star and put down the results of his observations almost every night. This work became the foundation for our knowledge about the Supernovas.

In November 1577 a bright comet appeared in the sky. Brahe observed it for three months and then compared his observations with other astronomers` results. He came to a conclusion that comets were not atmospheric phenomena as it was held by Aristotle but extra-terrestrial bodies that were at least three times as far from us as the Moon. He verified his model on other six comets.

Brahe compiled a star catalogue where he described 1004 stars. After decades-long observations he discovered two new irregularities of Lunar Motion.

This is just a small part of Tycho Brahe's accomplishments. His legacy includes archives containing his daily observations during a quarter of a century.

Brahe's student J. Kepler used this archive to develop the laws of planetary motion in the Solar System. [6]

**Example 125:** (*From M. Rubin's card index*) The father of science fiction, a great French novelist, poet and playwright Jules Verne left to us a card index with 20 000 records. Each record was the size of a school notebook full of information.

**Example 126:** (*From M. Rubin's card index*) Leonardo da Vinci's archive consisted of hundreds of sketches which included faces of different types, phases of movement of a human body, anatomical details, etc. He drew everywhere, even in the market place. Some of Leonardo's sketches are available here: http://www.liveinternet.ru/users/ludiko/post148549705/.

The problem is that an ordinary human cannot keep all this information in mind, let alone using and comparing **all** these facts continually.

But humans have invented an excellent aid – a card index. The initial stage of creative work is collecting observations, results of experiments, excerpts from literature, the Internet, etc.

However, you will soon notice that some of your cards are similar to others. They might have common details, functions, properties, origins or structure. Here comes the second stage of work with your card index: developing a subject index with cards arranged into groups.

From the start, a real research card index should aim at making discoveries and finding new conceptions. Collecting information for it may take a lifetime, but such card indices make for new discoveries and inventions.

As a matter of fact, a research card index is an extension of your thinking. The more material it contains, the more subject matters it incorporates, the broader is your mind. People collecting it start seeing much more than before, and their mind goes on broadening during their whole life.

**Example 127:** Geologist Charles Lyell undertook to write a manual on geology. While gathering material for the work, he found considerable discrepancies in geological theories of that time. Lyell decided to clarify this issue and gathered a huge amount of material that included other scientists' works and his own observations. In the end, he developed his own model and theory of geological evolution. His biographer M. A. Engelghardt described the changes in Lyell's thinking as follows:

*"Armed with the key to deciphering geological chronicles, he found illustrations of his theory everywhere. The letters he wrote during this period differed greatly from his previous writings. They demonstrated great observation skills, vivid interest in nature; we see a passionate natural scientist though not a deep thinker yet.*

*He became the king of his domain who had harnessed the chaos of phenomena. He easily deconstructed the most difficult, puzzling strata, chaotic masses of rock; he recovered the mechanism of various activities that had resulted in accumulation of these piles during ages, the mechanism that did not differ much from the modern one which Lyell could see in the eruptions of Vesuvius and Etna, in floods on the Po, and in the surf of the Mediterranean".* [52]

## Plantations of Conceptions

Creative work starts with a conception. A conception is like a seedling of talented thinking. A card index is a field where talented thinking grows.

A conception, in its turn, often starts with a single piece of information or a fact. It is a seed, a grain that must find its way to fertile soil.

**Example 128:** (*From M. Rubin's card index*) Life on the Earth is inexorably connected with geological processes: composition of the air, the crust of the Earth, the ocean. Vladimir Vernadsky`s idea became the basis of a new science – biogeochemistry, which developed from a single piece of information:

*At the end of the 19th century an English natural scientist doctor Carruthers observed a colossal migration of grasshoppers from the coast of Northern Africa to Arabia over the Red Sea. Thick clouds of insects swept over the researcher`s head for three days overshadowing the Sun and making alarming noises. This phenomenon was quite usual for the location but it struck Carruthers with its immense scale. The scientist decided to assess the number of insects in one of the clouds that passed over him on November 25, 1889. The cloud proved to have covered 5,967 square kilometres and it weighed 44 million tons.* [25]

Entomologists (scientists who study insects) showed no interest in Carruthers` information but geologist Vernadsky found it extremely interesting. The weight of just one cloud (44 million tons) was equal to the entire amount of copper, lead and zinc extracted by humans in the 19th century. This fact impressed Professor Vernadsky greatly. He filed the information separately under the name "Living Substance".

Special attention must be given to the fact that the new conception appeared when the seed of information about insects fell into new soil – geological. Moreover, it failed to grow on its native entomological soil. This is another reason for collecting card indices from a wider range of subjects. Bringing together completely different spheres of knowledge provides ideal "soil" for growing conceptions.

The next step is taking care of the seedlings so that they develop into new conceptions. They have to be watered with torrents of new facts, fertilised with reflexion and comparison of these facts. Thereupon the small sprout will grow into a branchy tree of discoveries, inventions in any sphere of human activity.

*"Carruthers' short note highlighted Vernadsky's path for decades. Gradually, the file with a blue cover was being filled with more and more cards. Corals, calcareous algae, a thousand-kilometre wide plankton films in the ocean – these masses of living matter could easily compete with masses of bedrock. This correlation between the living and non-living matter led Vernadsky to the idea that methods used for studying*

*minerals were valid for studying composition of the living matter as well. One of the results was discovering microelements in living organisms. Over years, examples from the blue file named "Living Matter" moved on into lectures, articles and books."*

But it was not the end of it!

*"The idea of the inseparable interrelation of the living and non-living matter gave Vernadsky the key to new discoveries and hypotheses. So far, the origin of life on the Earth is among the unsolved riddles. Prof.Vernadsky found quite an unusual approach to it. It is generally accepted that the non-living matter is eternal in the Universe. Thus, we may presume that the living matter is eternal as well."*

This is the philosophical level of scientific research which started with one unit of information. [75]

## What Kind of Information Should Be Collected?

While reading a text, we come to understand that it contains something interesting for us but we usually do not realize what exactly is interesting. Sometimes after reading a text we cannot even tell what was interesting about it.

How to extract the necessary information from the text?

First of all, you have to follow **Rule 1**: collect **any** information that seems appropriate, not only the information that you are sure you need.

In other words, you should read books with a pencil in your hand or your hand on the "mouse", so as to mark the necessary fragment of the text at once and put it into your card index. Do not depend on your memory – there is nothing more deceitful on the Earth. Do not forget to provide a full reference for every fragment you have copied, in order to be able to refer to the source text if necessary.

Stick to **Rule 2**: gather information not only about the primary subject, but on **associated, expanded** and possible **super-subjects** as well; gather **examples and quotations** that illustrate all these subjects.

A research card index is a special tool. It simply makes our mind see more, look deeper and wider. As soon as you come across a broader topic, you feel the need to understand it; however, to study it, you have to find new material and new information. Why not accumulate this information **before coming across the** new subject?

Let us assume that you gather information on the history of pedagogics and you find the following pieces of information.

**Example 129:** Led by the example of an ingenious Russian pioneer-chemist and scientist Zinin the founders of the Russian school of chemistry believed it was their duty to work in the same laboratories where their students conducted their own experiments. This method played an important role in the development of the Russian school of chemistry. [26]

**Example 130:** Finally, objective reasons why girls move to live with their "betrothed" husbands long before they reach sexual maturity have to be explained and the actual meaning of this step has to be discussed. Maybe the reason was that elderly men took pleasure in sexual intercourse with young partners? This was the obvious conclusion made by Groote Eylandt`s missionaries in 1941, which was probably shared by the majority of European researchers. While supposition that sexual intercourse with young girls was not prohibited among aboriginal tribes in their traditional setting might be true, the reason for the so-called early marriages with eight-year-old girls was quite different.

When a girl moved to her betrothed husband, he already had at least one older experienced wife. The newcomer had to live with her husband and his wives for a few years, and only then they had children. As has been mentioned, the aim of this early transfer into husband's family was not to provide an additional sexual partner immediately. On arriving, the girl learned her future social and economic tasks from older wives. Obviously, the most appropriate instructors for the girl who had to live with her husband and his wives were the older women.

The initial training for a girl was provided by her mother who lived in a group of her husbands' other wives. However, due to exogamy and patrilocality, the girl's further life was supposed to run in a new family, often in distant territories with different ecological conditions. Suffice it to say, the sooner the girl was able to adapt to her new family as one of her betrothed husband's wives and to get acquainted with the surrounding nature, the better. For this reason girls parted with their mothers long before they reached their sexual maturity and joined groups of their betrothed husbands' wives. [73]

**Example 131: I**n Berlin in 1840s a university professor Heinrich Gustav Magnus rearranged a few rooms in his house to make a physics laboratory where he could work with his students. The university covered the maintenance expenses of the laboratory.

Magnus' laboratory had all conveniences that were possible in a private house. Young researchers not only from Germany but also from America, England and Russia were Magnus` students. [44]

All these pieces of information have the same peculiarity – successful education takes a group of people who are engaged in the same activities, with the teachers working among their students. Such groups have existed in different epochs and in different societies. Now we will pay attention to correlated pieces of information and learn to recognize them immediately.

**Example 132:** How did Australian aborigines succeed in approaching a kangaroo unnoticed closer than at an 18-metre distance? First of all, they had to track the animal, and these excellent abilities of aboriginal tribes are often described in books. But what specific qualities did these people have to possess to be able to approach the animal after having spotted it at a distance of about 200 metres? This ability is completely different from the one they need to track the animal; still, it is rarely discussed. Above all, it required profound knowledge and understanding of the animal`s behaviour. In other words, aboriginal people were supposed to be excellent practicing ethologists.

The necessary knowledge was acquired in two ways: firstly, during their own practical experience of hunting; secondly, in the course of their training for initiation provided by older experienced men, which was equally important. The training comprised not only passive learning and repetition of myths and songs about various animal totems, which had very high ethological value; it also included imitation of animal behaviour. Guided by the elders, young men had to imitate animal behaviour. This was a very important educational part of the initiation and imitation rituals. Besides, this process went on for many years; an initiated young man broadened his knowledge of animal behaviour in addition to his practical experience of hunting. [74]

**Example 133:** (*from Butlerov's memories – J. M.*) Little by little, I started working mainly under the guidance of N. N. who conducted not only his own research but found interest in reproducing experiments of other scientists. While entrusting his students with the duties, he usually managed to conduct a great deal of any experiment by himself. Together with him we carried out a number of already known at that time experiments with derivatives of uric acid, prepared derivatives of indigo, worked on products of destructive distillation of "dragon's blood", obtained malic, gallic, formic, mucic, oxalic acids, etc. Considering the diversity of experiments, whether they liked it or not, the students had to get acquainted with different divisions of organic chemistry. This acquaintance occurred naturally and turned, as one might say, into flesh and blood because real substances from this or that division were in front of our eyes constantly. [25]

**Example 134:** Butlerov's students had this privilege. The very theory of chemical composition was created in front of their eyes, in their presence. Not only were they able to receive an answer to any question from the very creator of the theory but they had a possibility to follow any twists of his thought, to grasp its tiniest shades. This allowed them to see or at least guess the process of creative thinking, not just assess the final results.

Due to this system, Butlerov's students mastered more than just ready-made knowledge – they mastered the methods of knowledge acquisition. Many of his students such as Makrovnikov or Zaitsev later followed in their teacher`s footsteps. [27]

If there are cultural and historical conditions that help acquire good, creative education, then there must be some inverse conditions that support dogmatic, formal education. Now we can easily find some examples.

**Example 135:** There was a school named *The House of Tablets*, which was probably named after the clay tablets used for writing and arithmetic. There was a senior teacher addressed as "Master" or "Father-teacher". There was a class supervisor whose basic task was to monitor students' behaviour. There were special teachers who taught the Sumerian language and mathematics. The senior teacher had assistants who were called "Father's Brothers", and their duty was to maintain order. [84]

**Example 136:** Every artist was supposed to master the art of calligraphy and acquire the ability of precise and accurate stone carving. They had to be able to carve images as well as hieroglyphic symbols. The training was over once the artist had mastered these skills. These people were not expected to do anything else, anything specific. On the contrary, it appears that those who could make the best replicas of the great monuments of the past were considered to be the best artists. This is why for more than three thousand years Egyptian art changed so little. The art that was thought to be worthy and beautiful in the epoch of pyramids still held its positions thousands of years later. Indeed, the living environment changed and new motives appeared but the way of depicting human beings and nature remained almost the same. [22]

**Example 137:** Thus, the first thing the manuals do is narrowing the scientists` perception of the history of the scientific subject and filling the hollows that appear with surrogates. [45]

Here, a new theme appears which is much wider than the initial one: which cultural and historical situations facilitate creative education and which ones suppress it?

Would not it be sensible to accumulate material on the supersystem of education? After all, we have always known that education is only one of the subsystems of culture.

## Information Will Find You

Another serious question: where can we find information for card indices? The answer is quite as serious – everywhere!

We already know that information is chosen to prove or explain the concepts, and concepts stem from information. The universal dilemma “the chicken or the egg” is quite relevant in this case. Well, it all begins with contradictory information that does not fit into our knowledge. But we already have a natural “card index” that comprises a significant amount of knowledge: it is in our head. We just have to remember it. Then unusual information will find us by itself.

**Example 138:** In his article “Personal Card Indices – Foundation of Creativity” M. S. Rubin writes:

*"It would be interesting to follow the regularities of formation (origin, creation) of civilisation data bases. Consider Pompeii – an excellent database preserved due to the eruption of Vesuvius. Another database - patent and invention description – was developed by inventors who wanted to protect their rights. This database laid foundations for TRIZ. What are the contributory factors for formation of civilisation databases? Can we monitor and influence these factors or shall we just take them into consideration during our research?"* [75]

When I was reading this article, I experienced an immediate flow of information in my head which I had previously read somewhere and sometimes put down into my card index without paying much attention to it. For example, I read a book on the culture of Old Russia where it was written that the greater part of information about early Novgorod was retrieved due to… fires. The wooden city burned often and quickly, and the layers of ashes have preserved thousands of birch bark manuscripts – official and household writings of Novgorodians. Birch bark would not have survived open to the elements. Ashes stored these priceless documents of the past.

Does it not resemble Pompeii? Hence we can develop a generalisation or a hypothesis: what if we have to study catastrophes in order to develop an immortal civilisation database?

**Example 139:** During one of my webinars I gave the audience a home task which consisted of fragments of my card index that had examples of dynamisation of systems. This is another law of development of systems – in the course of evolution systems become more dynamic, flexible, manageable, and even self-governing.

All the listeners detected this regularity, and some of them even distinguished particular stages in escalation of dynamism of the systems.

Later during our class I gave them other examples from my card index that I picked at random. My listeners were surprised when they discovered new examples of dynamisation on some of these cards. Moreover, they were able to remember a few more examples that they had previously come across themselves.

The world is full of information; you just have to see it. Conceptions are looking-glasses that highlight the necessary pieces on the general information background.

## Verification of the Model

The conception is forming, the card index is being collected, and the model is becoming more and more integrated and coherent. But at this stage our talented thinking faces one more endurance test.

The heroine of *Tale of the Snow White and Seven Dwarfs* repeatedly asked her Magic Mirror one question “Mirror, mirror on the wall, who`s the fairest of us all?” She knew the answer, so she might not have asked. Of course she was “the fairest of them all”.

A man who has built a model knows for sure that his model is adequate, beautiful and perfect!

Just as the heroine of the fairy-tale, the author of the model realises very quickly that the beauty of the model is far from being perfect. It has many inaccuracies, mistakes, it may be disproved with a number of facts, and its prognoses are not sustained by the final results.

Indeed, criticism is often unfair. But the author should be capable of assessing his or her model and seeing its drawbacks.

**Example 140:** After the discovery of super fluidity of helium, scientists all around the world made attempts to study this peculiar quality and develop the theory of super fluidity. Lev Landau supposed that at ultra-low temperatures helium consisted of two components – normal and superfluid (helium II). In Landau’s model, if helium at such temperatures is rotated in a glass, the depth of the meniscus[1] must depend on the temperature. Landau`s student, Elephter Andronikashvili, set such an experiment, but the meniscus did not prove to depend on the temperature!

Landau doubted the quality of the experiment, yet the results of repeated trial tests were the same. Landau insisted on inaccuracy of the experiments. Four years later Osborne got the same results as Andronikashvili. Even then Landau did not believe it.

Three more years had passed before Landau and Lifshitz wrote an article where they made an attempt to build a theory of rotation of helium II based on the criticised

[1] In hydrodynamics a meniscus is a curved inner surface formed in a liquid rotating around its axis.

experiments. But it was too late: the theory had already been developed by Feynman… [13]

In this situation Landau could not see the drawbacks of his model. He chose to doubt the results of experiments for a few years. The result was logical – the adequate model was built by another scientist. And this example is not the only case of this kind. Inability to see the faults of their models has often let down even the most talented people. But there are numerous examples of the opposite.

**Example 141:** Even today critics of Darwin's theory are not able to find as many holes in his theory of evolution as Darwin himself. On top of everything, the same critics make countless absurd and ridiculous errors.

**Example 142:** Isaac Newton devoted an entire chapter of his book to unsolved problems in his theory of light. It is quite peculiar that some of the solutions Newton proposed were subsequently used for refutation of his theory.

Even the most experienced, mature specialists are sometimes bound to make absurd mistakes.

We can write thousands of books that will urge their readers to be careful, critical, to verify and double-check everything. But these appeals fail to work. In such cases people usually refer to unverifiable phenomena: talent, intuition… Even talented people believe in that.

## How Old Is Researcher?

How old must you be to start collecting your card index? It does not matter!

**Example 143:** physiologist Hans Selye discovered and studied calcification – accumulation of calcium salts in the body tissue. He was 55 when he started gathering material on the subject. [80]

**Example 144:** writer Nikolay Gogol started his card index of Ukrainian traditions and folklore when he was 17. (*From M. Rubin's card index*)

**Example 145:** In your opinion, how old was the person whose card index included the following card:

*"Crocodiles have many peculiarities. For example, their mouth cavities do not have salivary glands, they do not have bladder, but stomachs of adult crocodiles are always filled with many stones. Why? Supposedly, the stones facilitate swimming providing considerable stability to the animal`s body"* [96] (*From N. J. Murashkovsky's card index*).

When this card was included into a card index of interesting biological solutions, its author was six years old. He did not collect this card index all by himself. Yet it was **his** personal card index.

Later he included examples from his card index into his lecture for teachers at TRIZ seminar. A number of his examples were used by a mature researcher V. I. Timohov in his book on biological effects.

Are small children able to make substantial conclusions? Let us consider the opinion of American palaeontologist Neil Shubin who discovered tiktaalik – the missing link between the fish and the amphibians.

**Example 146:** In the atmosphere of sensation stirred by the media, my son's teacher asked me to bring the fossil to the kindergarten and to tell the children about it. I readily brought a mould of tiktaalik to Nathaniel's group, and my mind was preparing for the chaos that I would have to face. But twenty five-year-olds behaved surprisingly well while I was telling them about our work in the Antarctic aimed at finding this fossil, and when I was showing them its sharp teeth. Then I asked the children: "What is it, in your opinion?" Many children held up their hands. The first child said that it was a crocodile or an alligator. When I asked why, he replied that the animal had a flat head with eyes on top of it – just like a crocodile. Also it had big teeth. Other children expressed disagreement. I chose one of them and he said: "No, no, it isn't a crocodile; it is a fish because it has scales and fins!" Another child yelled: "May be it is a little bit of both?" This is the very message that tiktaalik sends to us, and it is so explicit that even kindergarten children can see that. [95]

Actually, we can teach children to get accustomed to card indices very early. Children learn to draw conclusions (without realising that they do it) almost from the day they were born. Consider the following passage by a neurobiologist and theoretician, professor of psychiatry and behaviourism at the University of Washington, Seattle, William Kelvin.

**Example 147:** During the first year of life babies learn to distinguish between the categories of speech sounds they hear. By the second year of life they memorise new words that consist of sequences of standard phonemes. In the third year the child begins to recognise and choose typical combinations of words which are generally called grammar or syntax. Soon he or she starts pronouncing long structured sentences. During the fourth year the child forms rules of building sentences and insists that goodnight tales should have their usual endings. This sequence of development constitutes a pyramid, and its every lower layer becomes the foundation for the next one as soon as it appears. Four levels in four years!

Active establishment and development of neural networks takes place during this time. Prenatal neural circuits of cerebral cortex shrink or expand depending on the degree of the previous usefulness of the circuit. Some circuits help create new combinations of words and verify their meaning by special quality control mechanisms; then, surprisingly, they help create sentences that we have never uttered before. The “operational space” of our brain should incorporate some circuits that enable us not only to create sentences, but also make plans for the weekend, draw logical conclusions, analyse our next moves in the game of chess or even enjoy structured music with repeated interrelated melodies. [17]

The baby perceives the world (and it is an extremely creative activity indeed!) from the first moment of its life[2]. At the very beginning this world is limited to the baby’s family, room and his or her things. We all know that the child’s “working day” ends with collecting and putting away their toys. We also know that it is a very hard process. But is it necessary to put the toys in a pile or a special box? Why do not we arrange separate places for “animals”, “humans” (dolls) or bricks? This is already a kind of a card index, and the ability to classify things. In a few days’ time, when this method of classification has been rooted, you can change its principles. Put the red toys in one place, the green ones in another place, and the blue ones in the third place. The bigger toys in one place, the smaller ones in another. Soft toys to the right, hard toys to the left. Those given by the parents in one place, but given by other people in another place, and given by Santa Claus in the third place.

[2] Some data suggest that it happens still earlier – approximately on the sixth month of pregnancy.

In the early childhood it is impossible to introduce a time line: children have not got such experience yet. But there is something we can do; for example, new toys can be put separately. Still newer toys get a new place and the older ones are moved a little further. These places can be denoted with symbols – toys that were bought when you were five, and toys that were bought when you were six.

Creating private card indices is an extremely convenient and effective form of engaging children in creative activities.

## Believe or Not Believe

Can we believe any information? Can we trust it at all? One of the common arguments is “I have seen it with my own eyes!” But can we believe our eyes?

**Example 148:** Once at my seminar I asked the audience to describe tropical birds. Everyone answered that these birds were extremely parti-coloured, with bright colourful feathers. When I asked the people how they knew that, they replied: “We have seen them in the Zoo, in books…”

In fact, according to the famous explorer of Africa David Livingstone, tropical birds are mostly black or dirty-brown. We “see” only those few birds that have been brought to Europe by bird dealers. For commercial purposes, they usually bring colourful birds, which is quite natural. [54]

Information can often be falsified on purpose as well.

**Example 149:** Alongside with the original written documents of the Carolingian period, many forged ones have been preserved until our time. Not only did monks treasure their own documents, but they also made forgeries. They needed the old charters mainly for producing crafty false copies.

As a result the land property of monasteries grew very rapidly, usually at the expense of their weak neighbours, peasants from the surrounding villages. [56]

Yet most often there are more objective reasons for unreliable information:

- The author of the material is guided by a conception that is no longer pertinent.

**Example 150:** The 17th and 18th century scientists Christiaan Huygens, Immanuel Kant and others described inhabitants of other planets in the Solar System in great detail. They relied on Copernicus' conception of the equality of all planets. According to it, if there were inhabitants on the Earth, there had to be inhabitants on other planets as well.

- The author relies on his own inadequate conception.

**Example 151:** The theory of ethnogenesis by Lev Gumilyov was the first attempt to introduce the time factor into the studies of ethnic groups, and herein lies its great scientific importance. But the theory itself is a typical cyclic periodization with equal periods of development that is not consistent with the historical facts. Now we know that uniform cyclic periodization should be substituted by progressive periodization with irregular periods. However, Gumilyov, in order to sustain his conception, had to change the very notion of ethnos several times and suggest unreasonable interpretations for many events or periods.

- The author of the material uses unreliable sources.

**Example 152:** In William Shakespeare's chronicle "Richard III", King of England Richard is depicted as a deceitful, ruthless, lying and ugly person. This most definitely fails to correspond to the true historical facts. But Shakespeare used the materials of Thomas More who had, in his turn, taken them from the writings of John Morton, a sworn enemy of Richard III. For personal and political reasons Morton had deliberately slandered the King.

**Example 153:** Nikolai Ivanovich Lobachevsky was the first to try to use data of astronomical observations to determine properties of space and time. In his studies of stellar parallax he wanted to find out which of the two geometries, Euclidian or his own, corresponded to the real conditions in physical space. But the available quantities of parallaxes published by French amateur astronomer Dass-Montdidier were too high and far from being real. Lobachevsky came to a conclusion that in the space limited by distances to the closest stars the difference between the two geometries was so insignificant that it could not be detected by the methods used at that time.

- The author is sincerely mistaken.

**Example 154:** The geographical views of Herodotus and many medieval geographers were full of absolutely fantastic stories. They were not trying to deceive anyone. The authors were convinced of the veracity of their conceptions.

Any information can function only in the framework of a broader set of conceptions, a supermodel. However, supermodel dictates its own rules.

**Example 155:** It is a universal truth that the lion is King of animals. These majestic animals with huge manes are furious and brave, their roar is heard from far away and they fill human and animal hearts with fear.

But explorer of Africa David Livingstone writes that lions are cowardly and cautious. There was a case when a lion did not attack a harnessed horse for two days for fear of an ambush. Lions are neither furious nor generous. They do not jump on an animal`s croup but try to sweep it off its feet going only for its hips or throats. All talks about the majestic roar of a lion are uttermost gossip: lion’s roar does not differ from ostrich’s scream; moreover, some subspecies do not even have manes. Buffalos and adult elephants are a major threat for lions. Lions also flee from rhinos in panic fear. [54]

Such misunderstandings can lead to acquiring unreliable information. In general, any information is unreliable to a certain extent. The question is not how to find reliable information but how to build adequate models on the basis of the available information.

The answer lies only in the card index. If a particular piece of information is confirmed by information from other fields and all this information fits into a good conception, if this conception has a strictly determined domain of application where it can be accurately prognosticated, then the conception may be treated as adequate. This state of things will be valid, as we know, until new facts appear.

## Tasks on Card Indices

**Task 60:** Below you will find an extensive fragment from Richard Wrangham’s book “Catching Fire (How Cooking Made Us Human)” that is devoted to the history of culinary art. Mark fragments which you would include into your card index. Why do you find them interesting? What research issues arise from these fragments? What other information do you need to develop your ideas?

"Although humans fare poorly on raw diets nowadays, at some time our ancestors must have foraged on bush fruits, fresh greens, raw meat, and other natural food as efficiently as apes do now. What can account for the change? Why, given all the obvious advantages of being able to extract large amounts of energy from raw food, have humans lost this ancient ability?

In theory, some evolutionary mishap might be responsible for this failure in our biology: the genetic programme for a well-adapted digestive system could have been lost by accident. However, a mistake in evolutionary adaptation is an unlikely explanation for something as widespread and labour-consuming as cooking. As a rule, natural selection generates exquisitely successful designs; it is particularly right for structures that are as important and in such regular use as our intestinal systems. Our inability to digest raw food effectively should have been compensated by some acquired benefit.

Evolutionary trade-offs are common. Compared to chimpanzees, we climb badly but we walk well. Our awkwardness in tree climbing is due partly to our long legs and flat feet, but those same legs and feet enable us to walk more efficiently than apes do. In a similar way, our limited effectiveness at digesting raw food is due to our having relatively small digestive systems compared to those of our anthropoid relatives. But the reduced size of our digestive tract seems to enable us to digest cooked food with exceptional proficiency.

Cooked food offers two kinds of advantages depending on whether the species have adapted to the cooked diet. Almost all species take advantage of the spontaneous benefits regardless of their evolutionary history because cooked food is easier to digest than raw food. Domestic animals such as calves, lambs and piglets grow faster when their food is cooked, and cows produce more fat in their milk and more milk per day. A similar effect is registered on fish farms. Salmon grows better on a diet of cooked rather than raw fishmeal. No wonder farmers prefer to give cooked mash or swill to their livestock. Cooked food stimulates efficient growth.

The spontaneous benefits of cooked food explain why domesticated pets easily become fat: their food is cooked, the same as the commercially produced kibbles, pellets, and nuggets given to dogs and cats. Owners of obese pets who recognize this connection and see cooked food as a health threat sometimes choose to feed raw food to their beloved ones to help them lose weight. Biologically Appropriate Raw Food, or BARF, is a special diet advertised as being beneficial for dogs for the same reason as raw-foodists who advocate raw diets for humans: it is natural. “Every living animal on earth requires a biologically appropriate diet. And if you think about it, not a single animal on earth is adapted by evolution to eating a cooked food diet. This means the BARF diet is exactly what we should give to our pets.” The effect of this diet is reminiscent of raw-foodists’ experience: “You can always tell a raw-food dog; they look better, have more energy, are thin and vibrant,” says an owner of a golden retriever whose coat started glowing within a week of eating raw food.

Even insects may get occasional benefits from eating cooked food. Researchers who rear agricultural pests in large numbers in order to find out how to control them give each insect species its own particular recipe of cooked food. Larvae of the diamondback moth thrive on a roasted mix of wheat germs, casein, bean meal, and cabbage flour. Black vine weevils do best on thoroughly boiled and blended lima beans. Whether domestic or wild, mammals or insects, useful or pests, animals used to raw diets tend to fare better on cooked food.

In humans, who have adapted to cooked food, its incidental advantages are complemented by evolutionary benefits. The evolutionary benefits stem from the fact that digestion is an energy-consuming process that can account for a high proportion of an individual’s energy budget; it often takes as much energy as body movements. After our ancestors started eating cooked food every day, natural selection favoured those with short intestines because they were able to digest their food with lower energy consumption, which helped the body to spend its energy more economically.

Evolutionary benefits of adapting to cooked food become evident when we compare human digestive systems with those of chimpanzees and other apes. The main difference is that humans have relatively small body features. We have small mouths, weak jaws, small teeth, small stomachs, small colons, and small intestines overall. In the past, the unusual size of these body parts was mostly attributed to the evolutionary effects of eating meat, but the design of the human digestive system is better explained as a result of adaptation to eating cooked food versus eating raw meat.

Mick Jagger's biggest yawn is nothing compared to that of a chimpanzee. Given that the mouth is the entry to the digestive tract, humans have a surprisingly tiny opening for such a large species. All big apes have a prominent snout and a broad toothy grin: chimpanzees can open their mouths twice as wide as humans, which they regularly demonstrate when eating. If a playful chimpanzee ever fancies to kiss you, you will never forget the impression. Only a squirrel monkey weighing less than 1.4 kilograms has a mouth as small as that of humans. The size of our mouth cavity is not big either, approximately the same as that of a chimpanzee, although we weigh some 50 per cent more than they do. Zoologists often try to capture the essence of our species with such phrases as the naked, bipedal, or big-brained ape. They could as well call us the small-mouthed ape.

The difference in mouth size is even more obvious when we have a look at the lips. The amount of food a chimpanzee can hold in its mouth by far exceeds what humans can hold because, in addition to their spacy mouth cavities, chimpanzees have large and very muscular lips. When eating juicy foods like fruits or meat, a chimpanzee uses its lips to hold a large wad of food in the outer part of its mouth; pressing the wad hard to its lips the animal squeezes the juice, which it can do repeatedly for many minutes before swallowing. The strong lips are probably the result of adaptation to eating fruits because fruit bats, or chiropterans, have similarly large and muscular lips that they use in the same way to squeeze fruit wads against their teeth. As compared to them, humans have relatively tiny lips suitable for a small mouthful of food at a time.

One more digestive peculiarity is weak jaws. You can feel for yourself that our chewing muscles, the temporalis and masseter, are small. In nonhuman apes these muscles often reach all the way from the jaw to the top of the skull where they sometimes are attached to the bone ridge called the sagittal crest whose only function is to hold the jaw muscles. In humans, by contrast, the jaw muscles normally reach barely halfway up the side of our heads. If you clench and unclench your teeth and feel the side of your head, you have a good chance to prove to yourself that you are not a gorilla: your temporalis muscle barely reaches the top of your ear. We also have very thin muscle fibres in our jaws, one-eighth the size of those of macaques. The cause of our weak jaws is a human-specific mutation in a gene responsible for producing muscle protein called myosin. Sometime around two and a half million years ago this gene, called *MYH16*, is thought to have spread in our ancestors which subsequently led to our species having very weak chewing muscles. Our small weak jaw muscles are not adapted to chewing tough raw food but they work well with soft, cooked food.

Molars, the chewing teeth of humans, are also small: as compared to the body mass, they are smaller than those of all the other primates. Again, this peculiarity is readily explained by the changes in the food consistency associated with cooking. Even without genetic evolution, animals reared experimentally on soft diets develop smaller jaws and teeth. The reduction in tooth size results in appearance of a well-balanced system: physical anthropologist Peter Lucas has calculated that the size of a tooth needed to make a crack in a cooked potato is 56 to 82 per cent smaller than that needed for a raw potato.

Continuing farther into the digestive tract, our stomachs again are comparatively small. In humans the surface area of the stomach is less than one-third the size expected for a typical mammal of our body weight, and smaller than in 97 per cent of other primates. The high caloric density of cooked food suggests that our stomachs can afford to be small. Big apes eat perhaps twice as much per day as we do in relation to the body mass because their food is rich in indigestible fibre (around 30 per cent of its weight, compared to 5 to 10 per cent or less in human diets). Thanks to the high caloric value of cooked food we have modest needs that are adequately served to by our small stomachs.

Below the stomach, the human small intestine is only a little smaller than could be expected in relation to the size of our body, which proves that this organ is the main site of digestion and absorption, especially if we take into account that humans have the same metabolic rates as other primates. The large intestine, on the other hand, is less than 60 per cent of the mass that could be expected for a primate of this body weight. The large intestine is where our intestinal flora ferments plant fibre producing fatty acids that are absorbed by the organism and used as a source of energy. The fact that the large intestine of humans is relatively small means that it cannot retain as much fibre as the big apes` large intestines and therefore cannot assimilate plant fibre as effectively. But that does not matter. Thanks to high caloric value of cooked food we normally do not need the large fermenting potential that apes rely on.

Finally, the volume of the entire human digestive tract, including stomach, small intestine and large intestine is also relatively small, smaller than in any other primate measured so far. The weight of our guts is estimated at about 60 per cent of what is expected for a primate of our size: the human digestive system as a whole is much smaller than would be predicted on the basis of size relationship among primates.

Reduction in the size of our mouth, teeth, and digestive tract is consistent with the softness, high caloric value, low fibre content, and high digestibility of cooked food. This reduction increases efficiency of digestion and saves us from unnecessary energy expenses on supporting structures that would allow us to digest large amounts of fibre. Mouths and teeth do not need to be large to chew soft, high-calorie food, and jaw muscles reduced in size help us eat with less effort. The smaller size of teeth may reduce tooth damage and subsequent decay.

In case of intestines, physical anthropologists Leslie Aiello and Peter Wheeler state that compared to that of big apes, reduction in human guts size saves humans at least 10 per cent of daily energy expenditure: the more guts tissue in the body, the more energy must be spent on its metabolism. Thanks to cooking, rich-in-fibre food of the type eaten by great apes ceased being an essential part of our diet. Thus, the sequence of changes in the human digestive system makes sense.

Could the tight correlation between the structure of our digestive system and the nature of cooked food be deceptive? Pangloss, a character in Voltaire's Candide, claimed that our noses were designed to carry spectacles on the grounds that our noses supported spectacles efficiently. But actually spectacles were designed to fit our noses rather than the other way around. Following Pangloss's reasoning, in theory cooked food is similarly well adapted to the human guts that, in its turn, had earlier been adapted to another kind of diet - meat." [78]

**Task 61:** Below you will find a fragment from Howard Haggard's book "Devils, Drugs and Doctors: The Story of the Science of Healing from Medicine Man to Doctor" on the history of medicine. Mark the fragments which you would include into your card index. Why do you find them interesting? What research questions arise from these fragments? What other information do you need to develop your ideas?

"Knowledge of human anatomy is the first requirement of surgery, but Greek physicians did not possess it yet. They made a valuable contribution to anatomy but they did not dissect human bodies. In this respect, Greek religion was still more implacable than the Egyptian one. The great Greek physician Galen, who lived in the second century A.D., derived his knowledge of anatomy from the pig, the ape, the dog, and the ox. He assumed that the structures he found in these animals were identical to the structures in the human body. In Europe, for thirteen centuries the human breastbone was thought to be segmented like that of an ape, and the liver was thought to be divided into many lobes like that of a hog; the uterus was supposed to be in two long horns like in the dog, and the pelvis widened at the bottom like that of the ox. So strong was the belief in veracity of Galen's teaching among the clerics and physicians that when Vesalius, in the sixteenth century, showed that Galen's description of the pelvis bones was wrong, the excuse that was offered for Galen's error was that the man had changed his shape through wearing tight trousers.

With the decline of the Roman Empire the Arabs collected the manuscripts of Galen and other Greek physicians and used them in the brief but brilliant period of prosperity of Arab culture. Galen stated that surgery was a form of treatment subordinate to medicine. This conception appealed to the Arabs for they supported the view common to all Oriental religions that it was indecent or sacrilegious to touch a human body under certain conditions. The Arabs did much to promote medicine but they neglected the study of anatomy and surgery. In the Western civilization the books by Galen, which were all written in Greek, lay hidden in monasteries for centuries. When they were finally translated into Latin – then the language of learning – Galen's ideas were accepted by the clericals and were considered to be as dogmatic as the statutes of the Catholic Church. To question Galen was heresy. Under such conditions practical study of anatomy had no future.

In the early Middle Ages, there were no trained surgeons in Europe. The only men with any medical education were the Jews who learned from the Arabs. The Church forbade applying to the Jews for medical treatment, although the Church authorities themselves did not hesitate to do it in case of a serious disease. Neither in the Middle Ages nor even in the Renaissance period did physicians undertake any surgical work. Towards the end of the Middle Ages physicians started studying surgery but the knowledge they could receive remained purely scholastic as operations on the human body were not performed. Doctors` work was limited to dressing wounds. Surgical operations were performed by barbers or by travelling practitioners who used to set up their booths at fairs. The surgery of the time was so rough and barbarous that Gregory of Tours, in the sixth century, advised people to emulate the saints and endure their pain with patience rather than submit to surgical operations.

Until the very end of the eleventh century there were no surgeons even in the armies. After each battle, King of Norway Magnus the Good selected twelve of his most kind-hearted soldiers to care for the wounded men. The armies of the Ancient Greece had surgeons; in the fourth century before Christ, Xenophon had eight field surgeons for his “Ten Thousand” team. Sick and wounded men were sheltered in villages or cities, and on the move they were carried in the rear of the troops. They were cared for by the so-called camp-followers – women “from the baggage”, as Xenophon rudely put it. In Europe in the fifteenth century noble knights setting off to war took along their own physicians. There were no regular armies at that time, and such surgeons as Paré retired to their civil practices after each campaign. The overwhelming majority of the wounded soldiers were left to the ministrations of their companions-in-arms or to female camp-followers. The latter ones were mostly prostitutes, and they often equalled in number the regular fighting force.” [90]

**Task 62:** Below you will find a fragment from Svetlana Burlak’s book “Origins of the Language”. Mark fragments which you would include into your card index. Why do you find them interesting? What research questions arise from these fragments? What supplementary information do you need to develop your ideas?

“The ability to imitate sounds is of great significance for development of speech. But ironically, people as a rule are very poor imitators. Not every human (as opposed to, let us say, a starling or a parrot) can identically reproduce the sounds made by a tit, a cat or a squeaking door, even the reproduction of the simplest melody would seem quite difficult to many people. According to Pinker and Jackendoff, “even the ability to convincingly imitate a foreign or regional accent is rather an exception than a rule among human adults”; this is what makes it difficult for grown-ups to gain a perfect command of a foreign language, and this is why people genuinely admire talented parodists and imitators.

Still, nature made an exception for the language. Regardless of the complexity of pronunciation of the language, children at the age of three to five are able to reproduce all the subtlest shades of it: all the “extremely difficult” vowels and consonants, tones (if there are any), intonation of various types of sentences.

And, finally, the main constituent of the language for linguists is its grammar. Rapid acquisition of grammar in three-year-olds is often called “grammar explosion”: within a very short period of time a child shifts from the proto-grammar to almost full command of syntactical and morphological riches of the language. But does it mean that humans have inborn, genetically encrypted concepts of grammar? I would rather say no. And not just because DNA is technically incapable of coding grammatical data, as discussed in Chapter 5. Careful observations of speech development in children show that when children acquire speaking habits, the most important thing they develop is the ability to communicate rather than build grammatically correct sentences; moreover, different grammatical elements are acquired independently. Grammatical constructions that adults perceive as similar are acquired by children separately, in different time periods. During the initial stage these constructions are weakly linked, the role of grammar rules in children’s speech is faint and they have narrow range of application. Thus, if a two-year-old hears a phrase with an invented verb and incorrect word order and is subsequently asked to use this verb in another context, the child copies the incorrect order (experiments were conducted with children whose mother tongue was English – a language where word order is overwhelmingly important), but if a phrase with incorrect word order contains a familiar verb and the child is asked to use this verb in another context, the produced phrase has correct word order. This manifests that two-year-olds have no general understanding of verbs and nouns; they use structures as frames that can be filled, just like parrot Alex that inserted the name of the desired object into a phrase “I want…” The discussed period of speech development is called the Verb Island stage because the majority of possible frames are made of verbs: *give me a candy / doll / pussy; a car / branch / stool has been broken*, etc. (but compare: *more milk* / *grapes* / *juice*, where the frame is made by an adverb). According to cognitive psychologist Boris Velichkovsky, “it appears that a child at this age does not use a completed system of syntactic rules that apply to any verb but rather acquires particular chosen verbs with a set of typical grammatical constructions”. The very process of cooperation of separate “frames” comes later. If we give a phrase with an invented verb and incorrect word order to a four-year-old English native speaker, he or she will promptly correct the word order and use the given verb with other nouns at the experimenter's request.

Indeed, if an individual has very few language elements at his or her disposal and limited communication goals to pursue, there is no possibility and even no need to build a complex communicative system: one only has to learn a number of utterances which will ensure a communicative success in each particular case.

The age of "grammatical explosion" is characterised not only by "sudden" acquisition of grammar. By this moment the majority of neural circuits in the young brain have already formed. According to Patricia Greenfield, during this period Broca's area is developing, which results not only in the considerable development of speech but also by acquisition of diverse "integrated hierarchical skills". Besides, at this age children realise that many things consist of parts which have their own special functions. Neurobiologist Valery Shulgovsky states that "by the end of the second and the beginning of the third year a child begins to single out details of an object, e. g. children aged between one year ten months and two years attempt to pick a flower by its stalk, to grasp the lid of a sugar bowl by its handle, etc."; so the range of fundamental conceptions that determine elements of behaviour broadens. At the same time children stop to perceive phrases as units and come to dividing them into separate elements (nevertheless, some units are separated surprisingly late – some five-year-olds still invite their friends to "my-happy-birthday"). This constitutes a major difference in the way a language is acquired by children and by apes in the language projects: the latter, first of all, master separate words and only then start acquiring the ability to join them. [18]

**Task 63:** Below you will find a fragment from Gordon Childe's book "What Happened in History" devoted to the history of ancient civilisations. Mark the fragments you would include into your card index. Why do you find them interesting? What research questions arise from these fragments? What other information do you need to develop your ideas?

Both anthropological and archaeological sources cover a span of time roughly a hundred times as long as that covered by the oldest written records. Appearance of the first tools and the man as a species may date from about five hundred thousand years ago. (*According to modern scientists, 2 million years ago. – Ed.*)

These are approximate figures, and in any case they are so large that they mean next to nothing to most people. More important and perhaps more helpful for further consideration is the fact that there have been registered substantial changes in the landscape and relief of the surface of the Earth.

For instance, during the Pleistocene period Britain was part of the European continent. Much of what is now the North Sea must have been dry land, and men could have sailed along some river resembling the Thames to the place where it joined the early Rhine.

The main mountain ranges had already formed before the first ‘men’ started making tools. There is a point of view that such a giant rupture of the earth`s crust as the Great Rift Valley in Eastern Africa had already formed by the time men came to live on the continent.

There is no doubt that catastrophic changes in the climate affected the whole earth; three or four Ice Ages followed one another in high latitudes and were accompanied by periods of torrential rains in the now arid sub-tropical zones.

The snow caps and glaciers that today cover the mountains of Norway were growing steadily during the glaciation period and then slid down into the valleys, and eventually spread out in a huge ice sheet over the plains of northern Europe. Ice shields once also developed in the areas of modern Ireland and England and moved to join the Scandinavian ice sheet in the east.

The Alpine glaciers likewise are creeping down these days; however, the scale is different. In the past, the glaciers that now frame Lake Geneva high above it in the mountains slid down their slopes almost reaching Lyon in France. Now glaciers are a kind of icy rivers that flow down ten to twenty feet a year.

In Greenland and Antarctica we can see ice sheets like those that covered England and Northern Europe in the Pleistocene period; they ‘flow’ at a speed of about a quarter of a mile per annum. So we can only make guesses at how long it will take the ice from the mountains of Scotland to reach Cambridge or how soon the Scandinavian ice will reach Berlin. The process of glacier retreat or melting of huge ice masses was almost as slow.

But melt they did. The climate grew warm enough for hippopotami and tigers to live in Norfolk, and for rhododendrons, now at home in Portugal, to grow in Tyrol. And then ice spread once more, to start new glaciation over again.

Indeed, the majority of geologists admit four major Ice Ages or glacial periods separated by three inter-glacial warm intervals. Some scientists admit a still larger number of glaciations and inter-glacial periods.

Meanwhile the man witnessed appearance of new species of animals, though not all of them survived natural selection. In the first inter-glacial period some very interesting creatures appeared: the sabre-toothed tiger, the little three-toed horse, and the southern elephant. Survivors from the Pliocene were still competing with the newer varieties that eventually took their place.

To withstand the cold of the ice ages, species of the elephant and the rhinoceros (the mammoth and the woolly rhinoceros) acquired hairy coats. Such variations were presumably established in the process of natural selection and went on for many generations. It is worthy to note that reproduction of the elephants is notoriously slow.

The most curious of all the developing species turned out to be the Man. The first ‘people’ differed so radically in their body structure from any race living today that zoologists classify them as  a separate species or genus and refuse to apply to them the scientific definition of the man used today, Homo sapiens. They are called hominids, which is ‘man-like creatures’” [93]

## Conception of Talented Education. Basic Principles

*Alice: Would you tell me, please, which way I ought to go from here?*

*The Cheshire Cat: That depends a good deal on where you want to get to.*

*Alice: I don't much care where.*

*The Cheshire Cat: Then it doesn't much matter which way you go.*

*Alice: ...So long as I get somewhere.*

*The Cheshire Cat: Oh, you're sure to do that, if only you walk long enough."*

(Lewis Caroll, *Alice in Wonderland*)

We have considered some elements of the Theory of Talented Thinking. These are just separate parts of the way to real Talented Education. But this is not enough. We have to know where exactly are we going to and if we have not diverged to the usual "good old" education based on the same slogan: "Remember it well, children!"

Let us consider the very essence of Talented Education. We shall engage in it up to the hilt brushing aside any thoughts about bad students, old-fashioned teachers or "those officials from the ministry". We shall also abandon our favourite mantra "We will not see this coming soon…"

Modern Conception of Talented Thinking includes 5 principles:

1. Teach the principles of knowledge modification versus knowledge itself.
2. Teach not to use new knowledge but to create it.
3. New knowledge can only be created by individually conducted research.
4. Only a teacher-researcher can train a student-researcher.
5. Training field should not be restricted to a separate school but include the entire cultural environment.

Let us discuss each of these principles in detail.

1. **One has to teach the principles of knowledge modification and not knowledge itself.**

Nowadays pedagogy is concerned with training people who can skilfully recreate and use the acquired knowledge that is recognised as correct. If we care to educate truly talented people, we have to reject this aim. The world is facing a new situation: the content of knowledge is changing constantly and will continue to change faster than it can reach educational establishments.

Just imagine: roads are full of cars, trains run across the continents but we are still teaching children to tack up a horse. It is not an exaggeration: a considerable part of information taught at school dates back to the18$^{th}$ and 19$^{th}$ centuries. Moreover, even if we start teaching the newest knowledge at school now, we will always be behind the times. While we are engaged in introducing new information into our educational programmes, this knowledge will become outdated and replaced by more novel information. While we are bothering with trains, airplanes are flying over the oceans and astronauts are studying the planet from the space.

And this is not the end of it. On the other hand, new knowledge, new discoveries and inventions are tragically overdue. New sources of energy remain un-discovered, new medical preparations from serious diseases remain un-invented; there is severe lack of real works of art, and the empty space is readily filled with cheap hits, paltry rhymes and popular prints.

The next generation, the pupils we are teaching today will face the world with knowledge changing at an extremely rapid speed. Do we really want our children to waste half of their lives on acquiring outdated knowledge? Is this the fate we want for us and our descendants, for the world they will live in?

Fortunately, it is not all that bad. Knowledge changes consistently, not chaotically. Today not only we know that these consistencies exist, but we also know what they are.

Hence the conclusion: the object of new pedagogy should be **regularities in the change of knowledge and concepts**. Moreover, it has to consider not only scientific, technical, artistic and economic concepts but also moral and ethical standards that are bound to rapid changes as well. And these changes are fundamental! But the most important thing that matters is that they change in conformity with certain laws.

At this point we have a clear vision of the new, talented pedagogy. Its **object is consistent changes in conceptualisation**.

It will not hold that *the Phlogiston Theory is incorrect* and *the theory of oxidation is correct*. Instead, it will tell how and why **the Phlogiston Theory that was considered correct** in its epoch was abandoned in favour of **the theory of oxidation that was acknowledged as correct later**, and what other theories may stem from it and why.

It will not declare that *gender equality is right* and the notorious phrase *"the husband is the head of the wife"* is wrong but will explain why discrimination towards women appeared, what problems it solved and what new problems it brought, how it was improved by the gender equality, why other problems may be expected to arise and what solutions to them may be.

I want to draw your attention to the fact that we have to consider changes of concepts i**n all spheres of culture**. I am referring to the idea of universal Talented Thinking, the kind of thinking that keeps pace with the regularities of change of knowledge.

2. **One has to teach how to create new knowledge, not how to use it.**

Why is education necessary, in general? Consider the following opinion of one of the highest "education" officials:

*…to gain particular professional knowledge that in future, after a person has obtained a diploma will be used for the benefit of the person and the society and most importantly for earning a decent living and providing for the family.*

*Education provides better opportunities for carving out a successful career, for future accomplishments and prosperous life.*

*…education solves two tasks, or at least, it should. Firstly, it reproduces the professional structure of the society. In other words, it prepares specialists for mass or non-conventional production. And it also miraculously reproduces the status structure, the basic type of social stratification.*

It means that the aim of education is to secure the established order. Or, according to Arkadiy Raikin, a famous Russian comedian actor: "Forget induction and deduction, switch over to production".

What do we do with our education? We use it (in accordance with our abilities) to improve our life (and, they say, social life). Thus, **we consume** our education. What if the situation changes? If the product cannot be consumed any longer? Then we will start complaining that the good old days have passed. We have been schooled so well to consume canonised knowledge that we will stop at nothing to preserve it unchanged!

Stagnation and lack of development are not caused by some strange people but by ourselves. We have been successfully schooled for this.

Hundreds, thousands and even millions of talented people will no longer be able to ensure accelerated change of knowledge in all spheres of human life. They will simply not manage. They are not coping with it already. The only way out for the humanity is to understand that **each and every** human has to support permanent change of knowledge!

3. **New knowledge can only be created by individually conducted research.**

First of all it has to be stressed that I do not mean laboratory work based on confirming the necessary “truth” by a set of given methods; neither do I mean the notorious “projects” that aim at confirming a given idea in the framework of a particular ideology by means of a set of given methods. We have to understand that it is **impossible** to create new knowledge and concepts within the rigid framework of conventional paradigms.

What I mean is a proper research conducted at the highest level, in other words, creating and developing new conceptions and coming to breakthrough conceptualisations.

Common conceptualisations of how discoveries and inventions are made often revolve around “the syndrome of “Newton’s apple”: an apple falls on your head, you are struck by an idea, put it down on a napkin and – voilà! A new theory is ready. There is nothing more unnatural than this scheme. Twenty-two years passed from the initial conception to publication of the theory of gravity. Twenty-two long years of complicated research, calculations, changes of concepts, let alone the fact that the very idea of gravity between the Sun and the planets, and even its formula appeared long before Newton!

The period between the first notes in young Charles Darwin's diary and publication of his theory of biological evolution lasted twenty-two years and required intensive research, collecting and studying enormous amounts of natural materials collections, not taking into account the fact that the idea of evolution of living organisms had been proposed more than one hundred years before Darwin's works were published.

Even such seemingly inconsiderable subject as an unclear case of fogging of photographic plates near Crookes`s tube took Wilhelm Roentgen eight weeks of almost round-the-clock work. He even stayed in the laboratory for the night.

A high level research has a huge amount of transition stages; it requires a wide range of skills, including acquisition of Talented Thinking procedures.

A remarkable writer Andrei Platonov said the following: *"The point is that one cannot guess the truth, one can only obtain it by hard work: when the whole world runs through the working man`s hands turning into a useful body, then he might speak of full conquest of the truth".*

This is the essence of genuine, high level research: not to wait for mystical enlightenment but work at new conceptions; not to repeat universal truths but create new knowledge.

New methodology for this kind of research is being developed at the moment. It will allow training researchers of any age to conduct high level research. But there is a long way to go: the work is far from being accomplished. Your participation in this work will also be an investment into the new conception of education.

### 4. Only a teacher-researcher can train a student-researcher.

During the initial stage of work it has become evident that only a person conducting high level research can teach it to the others. Thus a fine idea to produce many geniuses in a short period of time turned into a multistage process that should begin with training researchers, including teachers-researchers.

One of the peculiarities of high level research is that new conceptions come to a researcher very slowly; moreover, the route of these new ideas is not always predictable. We still fail to formalize many things (I hope it is a temporary situation); they are developed in the course of the working process. So we cannot but use the medieval model "master-student". There is one exception: modern students-researchers armed with the Theory of Talented Thinking can and should promote new conceptions which are novel even to their teachers.

But what exactly should Teachers of Talents study? They might do research in some separate fields of their pedagogical branch. Yet it would be better if the scope of their research were as wide as possible. One of the unexpected results of high level research is that every new conclusion triggers dozens of new questions. Hence, there will be enough new subjects for everyone to research.

5. **The training environment should be the entire surrounding culture rather than a closed school.**

Until the age of 9-11 for boys and 8-9 for girls, they observe the behaviour of adults, play appropriate games and help the adults. On reaching the age, a girl goes over to the family of her betrothed husband and a boy moves to the family of his future wife. Under supervision of the older wives the girl acquires skills necessary for gathering food and raising children, but the boy is taught to hunt and orientate himself in the massive semi-deserts. At the end of the training period the boys pass a special exam and get the promised wife, and the girls become rightful wives.

This might seem an example of an underdeveloped society, but mind that there are no weak students with unsatisfactory performance in aboriginal educational system. Is it not the dream of our educational gurus?

It is our modern school that was changed into a reservation long ago. **If we consider its lifestyle, the content of the knowledge it gives and the tasks it provides, we will understand that it has nothing in common with modern environment.**

Developing the conception of Talented Education we do not have to dwell too long upon the issue of what the school should be like. We have to proceed from the idea that **there should be no school whatsoever!**

The entire surrounding life and culture have to become educational!

Indeed, this would require reconstruction of the entire human culture and not just the educational system. And it is a good challenge for our abilities and our mental force. This task is worthy of the Man!

Some minor attempts to introduce similar ideas have already been made; e.g. in Soviet times sportsmen were taken on excursions to their “native factories” – places where they were supposed to work; another example was application of arithmetic to the household accounting of the school. The highest achievement in this sphere may be the idea of “educating environment”: a child`s home environment was arranged so that it stimulated perception of the new.

However, educating environment has two major drawbacks. Firstly, it provides the same canonical knowledge and fails to give an opportunity to create individual knowledge. Secondly, just like the good old school it is a restricted and fractional environment. We will not be able to solve global transport problems through putting bigger saddlebags on our motorcycles.

What we need is Educational Culture! All of it!

We need shops where we can master arithmetic; roads that allow studying physics; construction sites with possibilities for the best physical training. Moreover, these should not be “mass events”: “Today, children, we are going to a shop!” No! Any child who has entered a shop on purpose or accidently should be able to get a lesson of arithmetic.

At this point we face the first problems, the first subjects for elaboration. Any teacher is able to tackle these subjects provided that the teacher will dare take them up.

- It is not clear yet how the elements of our culture should be arranged so that they performed their educational function without detriment to the basic functions. And how shall we coordinate operation of these elements?
- To be able to perform functions of arithmetic teachers sales people and customers should have some pedagogical training. This concerns all the mankind. How do we organize mass pedagogical training?
- Education of any person should be based of his or her individual experience. We cannot teach addition if the child has not acquired numerals. So, how do we immediately determine whether the child can or cannot identify numerals?

These are just some of the problems of Educational Culture. Many more are still to come. The very idea of research and development lies in considering these problems and finding the right solutions.

Finally, I want to remind you the most important rule of genuine research:

**We should not ask why something new will not work out; we must ask how to make this new thing work!**

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# Chapter VII.

# Problems of Educating 7-10 Year Old Children and Possibilities of Problem Solving

**Jurgis Murashkovskiy**

Five years ago I started teaching classes at the Psychoneurophysiology and Bioregulation Investigation Centre in Riga. Today the children I started working with are already 12 years old. I have a few groups of younger children and of those first pupils who continue to come to my classes.

In the course of preparation for my first class I supposed that I would provide some theory and then we would solve the tasks. However, when my first pupils came into the classroom, it occurred to me that my lesson will fail if I begin with imposing the theory.

While children were taking their seats at the table, I realised that they expect the classes to be interesting. I told them that during our classes we would find solutions to various difficult problems, and, what was even more important, they would be able to learn to solve such complicated tasks that not many adults could solve.

The children liked the idea but they still wanted to play. I knew that their desire was natural and there was no evil intent to it. Therefore, I invented a few games to start with. These games guided the class into the desired direction. The children liked the first class and decided to come again.

The following classes did not always go well, and I was not always able to grasp the problems before they arose and triggered conflicts.

Regardless of the results, I always made notes on the outcome of every class – the things I had planned and what I actually managed to do, why I was not able to implement the things I had planned, what I should do in the future to achieve the aims I had set for the lesson and how I should do that.

# Principles of Eliminating Contradictions

The aim of the lesson – to teach the children:

1. To formulate contradictory requirements of the given problems.
2. To mark conflicting properties of the contradictions.
3. To find resources that would eliminate contradictions arising from the conflicting properties.

It is not an easy task to prove that problems are solved easier if we approach them systematically and do not try to guess the solution.

7 to 10- year-old children have already accumulated some experience. They have already solved many problems by themselves, and this makes them think that problems have to be solved with their own effort. We should by no means destroy this confidence by giving our pupils difficult, insolvable tasks immediately.

On the other hand, we have to demonstrate that methods of eliminating contradictions can be used to solve extremely complicated tasks.

Hence, at the beginning of the training course we have to show the children that problems may be difficult and simple. The simple ones are those that we know how to solve, the difficult ones we do not know how to solve. The methodology of eliminating contradictions is necessary for solving complicated problems.

**Examples for Comparison**

**Task 1:**

What do you do to cool hot tea? (An easy task)

**The children's answers:** wait until it cools; add cold water; blow on it.

The result – the children feel confident, they can solve the problem.

**Task 2:**

What do you do if you have to take a seat at the table and start eating but the chair is too low and it is difficult to reach the table? (An easy task)

**The children's answers:** take a higher chair; put a pillow or a stand on the chair; take a plate and find a lower table.

The result – the children feel calm and they are assured of their capabilities.

**Task 3** (It is important to warn the children that this task will be extremely complicated):

An electric transformer placed on a small concrete stand in the yard of a residential area burned. The old heavy transformer has to be removed and taken to a repair shop; it also has to be replaced by a new one. [1] How can the transformer be removed from the stand without damaging it if we know that there is no possibility to employ a lifting crane?

The children start guessing and offering the most ineffective solutions: from doing nothing to calling a superman who can lift the transformer from its stand with one hand only.

When the children have exhausted all their ideas, you will have to propose some instruments for solving the problem:

1) First of all, we have to understand what we have to do: we have to free the space for a new transformer without damaging the old one.
2) Then we have to think of some possible variants of the solution and formulate them as contradictions taking into account supplementary requirements (formulate contradictory requirements for this problem):

   a. If we knock the transformer down off its stand, we will have the place for a new transformer but in this case the old one will fall and break down.

   b. If we do not knock the transformer down off its stand, it will remain undamaged but we will not provide space for the new one.
3) We choose the most crucial variant a. because it is more important to install a new transformer that will provide electricity for the whole neighbourhood.
4) Before we determine the conflicting properties, we have to understand what will damage the transformer: it will break because it will come down very quickly and hit the ground.
5) Let us mark the conflicting property: we have to eliminate rapid falling of the transformer to the ground.

6) Now we have to look for something that will eliminate the conflicting property, i.e. the hard drop of the transformer to the ground.

7) We could use ice; we were in a residential area. This was the actual solution. An ice stand was built next to the concrete stand, and the old transformer was moved from its concrete stand onto the ice stand. After some time the ice melted and the transformer gradually came down to the ground.

On finding the solution the children were very happy and said that the task was not very difficult after all. We should not forget to tell them that this task was not difficult because we did not guess the solution but used the method of eliminating contradictions.

Next you should consider other examples employing the methodology of eliminating contradictions.

During your classes you should not forget to analyse and solve, by means of this methodology, at least one real problem posed by the children themselves.

For example, mother does not let her daughter to go to a school party:

1) We determine the essence of the problem: the mother should let the girl go to the school party.

2) We formulate two variants of actions in the form of contradictions:

   a. If the girl goes to the party without her mother's permission, she will have fun but her mother will be upset.

   b. If the girl does not go to the party, her mother will not be upset but the girl will deprive herself of the entertainment.

3) We choose the most crucial variant a. because the main condition is that the girl should go to the party anyway.

4) Before we determine the conflicting property, we have to understand the reason why her mother will be upset. It turned out that the girl was too young and would not be able to stand up for herself if someone hurt her at school.

5) Let us mark the conflicting property: we have to eliminate mother's worries that someone might hurt the girl.

6) Now we have to find a way to eliminate mother's worries replacing them by a sense of security.

7) It turned out that the girl had a considerably older cousin who was attending the same school and was also going to the party in question. The girl arranged for herself to go to the school party together with her cousin who promised to keep an eye on the girl.

## Finding Resources for Eliminating Contradictions

The aim of the lesson is to teach the pupils to find resources for eliminating contradictions. Resources can be found:

1. In supersystems.
2. In subsystems.
3. In antisystems.
4. By resolving contradictions in time.
5. By resolving contradictions in space.

When children learn to formulate contradictions, they realise that in some tasks it is quite easy to find resources for eliminating the contradictory property, while in other tasks it takes a lot of time.

Only when the children themselves start asking questions about the possible ways of facilitating the process of eliminating contradictions, you can suggest looking for examples of such contradictions among the solutions which have already been found. In order to do this it is crucial for the children to remember the previously solved contradictions. To support them, you have to prepare a couple of examples with similar types of solutions, for example, tasks with the necessary resource in the subsystem:

**Task 1. Changing a flat tyre**

A person was driving in the countryside and got a flat tire. He stopped at the roadside, unscrewed the nuts carefully and put them on the side of the road. He removed the flat tire and took out the spare one from the boot. At that particular moment a motorcyclist was passing by and he accidentally threw all the nuts into the ditch on the roadside. The ditch was very deep, and it was impossible to retrieve the nuts. The nearest place where he could get help was approximately 12 miles (20 kilometres) away. How can the driver fix the tyre to make it possible to cover these 12 miles?

The tyre has to be fixed, but where can he find the nuts if there is nothing around him? The resource for solving the problem is in the car itself. It is possible to unscrew one nut from each of the other tyres to fix the fourth. If he drives slowly, he will definitely overcome these 12 miles. [2]

**Task 2. Ancient sailors.**

Long before humans invented electricity seafarers went to sea. Situations at sea when sailors had to fix something on the spot, e.g., sails torn by the wind, were quite common. In order to repair something sailors had to get the necessary tools from the hold and run back to the deck. The problem was that there was no light in the holds, so it was extremely difficult to find the necessary tools. Sailors had to wait until their eyes got used to the dark, and only then they could look for the tools. But if their ships were at stake, they had no time to wait for their eyes to adapt to the dark. Was there a solution for the sailors?

The sailors' eyes have to be accustomed to the dark when they go to the hold, but they cannot get accustomed within the short time while they are coming into the hold from the light. But luckily humans have two eyes. Thankful for this gift of nature, sailors wore a patch on one eye which always remained accustomed to the dark. Getting into the hold they took off this patch and could easily find the necessary tools. [3]

**Task 3. Boards of the Ship.**

In the 17$^{th}$ century big wooden ships in high winds would list to one side and sink. It took sailors very long to understand why this happened in spite of the keel installed under the ship to improve its stability. In accordance with the laws of physics, the keel had to prevent listing, but in high winds the keel took a list together with the ship. Why did this happen?

Again we have a contradiction: the ship has to list to one side because this is what actually happens, but it should not take a list because it has a keel. In order to take a list even with the keel, one side of the ship has to be heavier than the other. But no one could think about it. Ships were made of wood, and it turned out to be that the trouble lay in the boards the ship was made of. Different timber has different wood density, and if one side of the ship is made of heavier boards than the other one, their weight is different, and the ship can overturn. Finally, boards made of the same tree were used to assemble the opposite sides of the ship. The weight of both sides was the same, and the ship would not take a list even in high winds.

Children usually find that there are some common traits in the process of eliminating contradictions, and it is some kind of resource for solving contradictions. However, they cannot see that the resource is in the system itself. So, after some examples with subsystems, we have to provide tasks with resources taken from supersystems.

**Examples of such tasks:**

**Task 1. Supersystem.**

Logistics in the Hellenistic Period was extremely underdeveloped. Merchant ships carried goods to trade cities, sold them there and went back unloaded. However, a loaded draught of the ship is deep, which keeps it steady, while the draught of an empty ship is shallow, and the ship is unsteady.

Another contradiction. A ship has to be heavy to be steady in the water, and it has to be light because all the goods are sold. A resource for eliminating this contradiction is water, which is easily available in the ocean. Merchants filled empty barrels with water and so imparted stability to their ships. [4]

**Task 2. Supersystem.**

A space research centre organised an expedition with the aim to obtain a sample of soil on the dark side of the Moon. A remotely controlled lunar vehicle with specialised equipment was supposed to land on the Moon. It was equipped with a video camera and a spotlight which would enable scientists to highlight the sampling section. During trial of the vehicle on the Earth, namely, during simulation of the take-off, they found out that the glass of the spotlight bulb would crack. It was two weeks before the take-off, and the solution had to come fast because the flight could not have been delayed. [5]

The contradiction: the bulb has to be made of glass for the spotlight to highlight the desired section of the lunar surface, and it should not have glass because it cracks at the take-off. Glass protects the filament from burning in atmospheric oxygen, and there is vacuum inside the light bulb. There is vacuum around the lunar vehicle too as there is no air on the Moon, which makes the glass bulb around the filament redundant.

**Task 3. Supersystem.**

In Ancient China the Minister of War organised a coup against the Emperor. He planned to defeat Emperor's forces with the military fleet that was at his disposal. The Emperor had to counter the attack of the Minister with a handful of ships.

The contradiction: In order to counter the attack the Emperor's fleet has to conquer the Minister's fleet, but at the same time it should not counter the attack because the Minister's fleet is much stronger. And again an external resource from the surrounding environment was used, only this time it was not water, it was wind. The Emperor's general ordered to fill one of the ships with hay and let it sail to the Minister's fleet. When the ship approached, the crew put it on fire and jumped into water. The burning ship crashed into the Minister's fleet and the wind (a resource from the supersystem) spread the fire to all its ships. [6]

By comparing examples of eliminating contradictions the children come to understand that resources for solving them can be found not only outside but also within the system. When the children arrive at this conclusion, you should provide many more examples where conflicting properties are eliminated using intra-systemic and extra-systemic resources.

When the children have mastered finding resources in subsystems and supersystems, you may add the information that resources can be found in antisystems too. If the children are good at finding resources, they can try to solve their own examples; if they are still not confident enough, give them a few examples of using antisystems:

**Task 1. Antisystem.**

It is quite easy to dig a pit for building a house if the ground is warm enough: it is friable and easy to dig with an excavator. But if the ground is frozen, the shovel of the excavator cannot extract it. In cold areas the ground temperatures can be around minus 20°C and lower. It is impossible to dig a pit under such conditions, but it is too expensive to heat the ground.

The contradiction: for digging, the ground has to be warm enough, but it is always cold because it is in a cold place. In such cases the ground is not heated but cooled to still lower temperatures. It is cheaper than heating, and the deep-frozen ground becomes friable. [7]

**Task 2. Antisystem.**

A pancakes company developed a conveyor belt. The pans move along the conveyor and pass under a dosing pump that streams a portion of dough into them. Then the pans proceed to the oven, and the pancakes are baked there. However, due to the sticky texture of the dough, the dosing pump cannot stream an equal amount of dough each time. If there is too much dough on a pan, the pancake remains underbaked; if there is two little dough, it burns. [8]

The contradiction: in order to make good pancakes the portions of dough have to be the same on all the pans; on the other hand, they should not be the same because the dosing pump cannot stream equal amounts of dough.

The solution is in the antisystem. The pans are turned upside down. If there is too much dough, it simply flows off the bottom of the pan.

In the same manner you should provide the children with tasks for resolving contradictory properties in time and in space.

## Principles of Coining Terminology

We have to teach the children to create terminology by themselves. They should be able to name their solutions or unknown phenomena they invent or discover. For example, if the children understand that one tree can be heavier than another one but they do not know the word “density”, then the task about a ship in high wind can cause difficulties.

The following tasks will train the ability to invent terminology:

**Task 1. Terminology.**

Imagine a new animal which is a hybrid of other animals but with different characteristics and habits, e. g., a cat that produces honey like bees do; describe the habits of this animal.

For instance, a dog that has a wheat spikelet instead of the tail can be named *wheatog* or *spikhound*.

Invent other names for such habits as eating, mating or sleeping for particular animals. For example, a spikhound feeds on wheat that grows instead of its tail and so chasing its own tail is a vital necessity. Spikhounds' food might be called a wheat roll.

**Task 2. Terminology.**

Think out a funny pastime and name it on the spot.

You should repeat these games on a regular basis in order to strengthen the ability to create terminology.

## Creating Card Indices with Examples

Children are very happy when they can solve interesting tasks; at the same time they acquire new knowledge.

We should not forget that we have to teach the children to formulate contradictions on their own, to come to their own conclusions about the ways of solving various problems in real life situations. The most important thing is that the children cannot limit themselves to the already known methods of solving problems; they have to be ready to discover their own methods and to create their own models of knowledge.

This is why it is crucial that the children prepare their own examples of contradictions for the classes from the very beginning. If you have one class per week, make a tradition of analysing the examples of contradictions provided by the children themselves, and do it once a month.

After introductory classes, the children should be able to notice contradictions all around them. For example, if we have solid paper, it is hard to tear it; if there are many pieces of paper, it is difficult to pull them together. There is a solution: resolve these contradictions in space. The section that has to be torn is perforated with a line of closely spaced holes. These holes do not separate a piece of paper from the whole list, but at the same time it is easy to tear off the perforated piece. This principle is used in making paper towels.

If the children cannot find these contradictions by themselves, you definitely have to do it together.

It is advisable that the children do not focus on examples from one sphere of life. Let them consider contradictory situations from the most diverse spheres and encourage them to create their own collections of contradictions – card indices.

It is not mandatory for children to start creating their own card index of contradictions immediately. At first, you should teach them to notice special characteristics of various situations and use the information for their own purposes. Marking and using properties is an excellent task for training.

**Task:**

Every child is offered an object, e. g., a volcano, a whirlpool in the Galapagos region, a giant tree, a desert, a waterfall, etc. Everyone has to collect information about his or her object and has to persuade the other children to go on a trip and see this particular object. On the one hand, the task is very simple and naive, but on the other hand it is interesting and exciting. The children learn to collect and use information on their own.

## Working with Children: Common Problems

1) Children do not understand why the task is necessary.
2) Children cannot concentrate because:

   a. the task is not interesting.

   b. they are tired (physically).

   c. they want to attract everyone's' attention

   d. they lack such general abilities as good memory, reading or writing skills.

Children can acquire the principles of eliminating contradictions, for example, formulating contradicting requirements or marking conflicting properties only if they understand why they need it. If a child fails to understand why is it necessary to solve contradictions which are not connected with his or her life, it will be difficult for the child to apply the methods of eliminating contradictions outside the classes on his own. One of the main problems is that even if the children have mastered the principles of solving contradictions, they are afraid to apply them in real life situations, and the ability to solve contradictions remains a fantasy.

For this reason I try to begin my classes with finding out what problems each child in the group would like to solve. Afterwards I use these problems together with my own examples during the classes.

I prepare examples of contradictions (tasks) that are appropriate for the age and group of my students.

When we solve the problems of particular children, we give them a possibility to enjoy attention of their peers. The ability to attract other people's attention is extremely important not only for children but for adults as well. Hence, during my classes I try to treat my pupils` needs with due respect.

I also pay attention to their inability to concentrate, e.g., on reading. The ability to read fast will be essential for the children; therefore I try to make them want to read themselves. We often sing karaoke at the end of our class. The children enjoy this activity, but at the same time they have to read the words of the songs very fast.

In the same manner I try to solve any problems that I face during my classes.

This is the reason why it is crucial for teachers to be able to solve contradictions. This is the reason why teachers should treat their own mistakes not as something shameful but as an extremely important resource for their own development. The ability to see one`s own mistakes is also an important quality of talented thinking!

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# Chapter VIII.

# Good examples and stories from teachers

## How to develop talented thinking in classrooms by using exercises based on TRIZ method (Theory of Inventive Problem Solving)?

## Exercises

**Jurgis Murashkovskiy**

### Lesson 1. Introducing one-self

Of course, it is necessary to introduce one-self. Getting introduced can be combined with a dose of motivation for learning the subject.

**Exercise 1.1. What is your name and who do you want to be?**

Every participant of the lesson tells their names and what they want to become when they grow up.

*Expected result:*

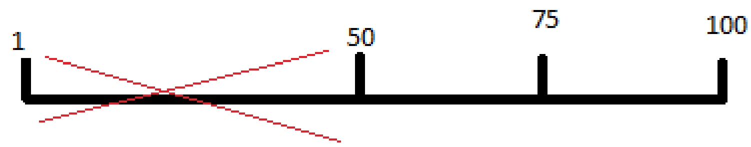
1) Everyone gets acquainted;
2) Children like to tell about themselves, they have an opportunity to speak already from the very beginning, and that raises interest about the lesson;
3) The teacher has a possibility to ask every participant if they will need to solve problems when they grow up and become people they wish to become. Since usually they all agree that everyone needs to solve problems, the teacher can clearly state that we are also going to learn how to solve tasks.

After getting acquainted, it is necessary to offer to play a game that will help to solve many tasks faster. This game is called “YES – NO”.

**Exercise 1.2. YES – NO questions**

The principle of the game "Yes – No" is that anyone imagines something (a riddle, a situation, a number, a fruit or something else), but other participants need to guess it by asking questions to which the leading student can only give the answer "Yes" or "No".

An example that the teacher is advised to give students: the teacher chooses a number from 1 to 100 and offers students to find it. Most frequently children would give particular numbers. In this case it is necessary to explain them that they can guess in this way for 100 times, and that would take a lot of time. Due to this reason it is better to ask questions that would at once exclude a half of all the possible variants. A sample question: "Is this number greater than 50?" If the teacher says "Yes", then children need not ask about numbers from 1 to 50 anymore. The example should be drawn on the board.




When the number is guessed, children should play this game among them, only not with numbers anymore, but with vegetables or fruit. Everyone in their turn must imagine a fruit, but others need to guess this fruit. Students also need to learn how to ask generalizing questions; not simply try to guess the particular fruit, but ask questions: is it a berry? Is it sweet? Is it of feminine gender? etc.

*Expected result:*

1) Children learn to ask generalizing questions, thus they also learn to decrease the search range;
2) They learn to group objects according to their properties.

Further on, in order to strengthen the skill of generalizing and to distinguish not only properties, but also qualities, it is possible to play the game "Sellers – buyers".

**Exercise 1.3**. **“Sellers – buyers”**

Children are divided into two teams, for instance, “wolves” and “cows”. Every team, by taking turns, try to sell to another team an object that they definitely have no need of. For instance, wolves must sell meat to cows, while cows must sell hey to wolves. At the same time the buying team must have a single condition upon which they would still buy this completely unnecessary object. For instance, cows would stick meat in ears during full moon so that howling of wolves would not interrupt their sleep.

*Expected result*:

1) Skill of scaling down the search range is strengthened;
2) Children start to understand that properties and qualities of objects can be used for non-standard goals.

Further, so that the skill to determine properties would not seem to be just a game, this skill must be applied to achieve practical benefit.

**Exercise 1.4**. **Method of focal objects**

Everyone thinks of an object they want to improve. Then they choose three other random objects and determine their properties. The determined properties are added to the object to be improved, the student should also think how to create a new, improved object.

*Expected result*:

1) Children understand how to use properties of objects and create new objects;
2) The fear of inventing new things disappears.

**Exercise 1.5**. **Brain storm**

Children are given exercises (these can be exercises of logics or riddles) to which they must give answers during brain-storming in a hierarchical order. According to the brain storm method, everyone must say a word, but the person with the lowest rank is the first to express his idea of solution, then those standing on higher hierarchical steps present their answers.

The task of every student is to determine the parameter according to which he is in the lowest point of hierarchy – the lowest rank. So that he could answer as first.

*Expected result*:

1) The notion of hierarchy is learnt;
2) Students can form hierarchy according to various parameters;
3) The fear of being "worse" than others disappears.

In order to strengthen the understanding of hierarchy and children would learn to order everything around them according to hierarchy, we need to offer the last game of the lesson.

**Exercise 1.6. Hierarchy of objects**

Everyone receives a group of objects. The student has to decide independently upon which parameter he can build the hierarchy of the existing objects. For instance, order the planets of the solar system or desks in the classroom according to the hierarchy principle.

*Expected result:*

1) The notion of hierarchy is strengthened;
2) Children understand not only the notion of hierarchy, but are also able to create hierarchy steps.

## Lesson 2. Contradictions of characteristics

**Exercise 2.1. Drawing a supercar, determining 3 good and 1 bad quality**

For 5 minutes children draw an ideal car according to their considerations. When the time is over, children must tell about their car. At the end of the story they need to summarize: name 3 positive qualities of the car and at least 1 negative quality. Such answers as "the car is good as it is cool" are not good enough, they need to say what exactly is good in the fact that the car is cool.

*Expected result:*

Children learn to understand what a result and a quality are. They also learn to generalize, in a word – to describe a good quality. In addition children learn to determine shortages that also influence the generalizing thinking and prove that there are always shortages, but we need not fear that.

**Exercise 2.2. Reviewing the exercise**

In Antiquity, in many countries a great part of trade went through sea. Ships full of cargo went to other towns and sold all goods. Then they returned back empty. An empty ship does not sink into water and can be easily turned over.

The exercise perfectly illustrates that properties quite often change in time and space. The ship was heavy, but became light on its way back. We should ask the question: which property of the ship should be changed on its way back? Namely, we need to eliminate the lightness of the ship on its way back. But how to do it? (The exercise answer is to fill empty barrels from goods with sea water.)

**Exercise 2.3. How can a plane fly faster?**

Airplane needs long wings in order to take off faster, but long wings create greater resistance during flight. We must ask the question: which property is hindering fast flight? What should be changed during the flight?

The answer of the exercise is that wings are drawn in or folded back during the flight.

*Expected result:*

Children understand that, when a problem occurs, one of the solutions may be changing a property in time.

## Lesson 3. Contradictions of supersystems

**Exercise 3.1. Characteristics in a supersystem**

Tell children how fins of flying fish are different. How are these fish different from common fish that do not fly? Most probably they differ in the way that they change their natural habitat (water) to another habitat (air).

Further students should receive a task to imagine how a house would change if it is moved under water or in the air.

Students should be asked to imagine their own individual object and change its natural environment, as well as imagine a story about this object. For instance, if current would run not through wires, but through blood-vessels?

### Exercise 3.2. Grouping characteristics in a supersystem

During the Arabic reign in Spain, it happened that in the territory of one country lived people of Islamic faith and culture as well as people of catholic (Christian) faith and culture. They should live together somehow. They also had to build houses. But the thing is that houses are built in a different manner in every culture. For instance, the Alhambra castle functioned as protection and everyone had to dwell in it – both Catholics and Muslims. But, if the castle were built in the Arabic style, Christians would not want to stay in it, yet, if it were built in the Christian style, Arabs would not want to stay in it. One of the castle towers solved the problem in the following way – it had an Arabic dome from the outside, but the inside was ornamented with characters from Christian stories. It is the dome of the Hall of the Abencerrajes.

### Exercise 3.3. Changing characteristics in a supersystem

As the first sculptures of Christ appeared in Rome, it is obvious that the facial features reminded a European since the God created a man after Himself. Everything is fine for Caucasians, but what should representatives of the mongoloid race do? If they see statues with Caucasian features, they would not look like mongoloids, yet in the Bible it is said that the God is similar to the man. A bright solution is the Christ sculpture in Perm, it is created as a Komi-Permyak and is called “the sitting Christ”. The statue’s face presents clear Mongoloid features. The sculpture is dressed in a vest, just like the very Komi-Permyaks used to dress. But the sculpture’s head is covered with a crown, it also shows a haggard looks as a Christ’s statue should.

*Expected result:*

Having examined the exercises, students guess the answer, but, if the sense of supersystem is poorly developed, then most probably there will be no answer. Students understand how tasks are formed in the supersystem and what type of tasks should be solved on the supersystem level.

## Lesson 4. Formulating contradictions

Transition from a vague inventive situation to a clearly formed and ultimately simple task scheme (model).

**Exercise 4.1. Charlemagne's coronation**

In the Middle Ages the coronation ceremony of a new king was led by the Pope of Rome. This meant that the king abides the Pope of Rome. When Charles the Great had to become the king, he decided that he should not abide the Pope of Rome, thus he would himself put the crown on his head. But, if the Pope of Rome would not lead the coronation ceremony, Charles would not become the king. How should Charles the Great manage the coronation ceremony so that he should not abide the Pope of Rome?

What supersystems have caused the contradiction? The supersystem of the coronation ceremony requires that the Pope of Rome would place the crown on the king's head. The political supersystem requires that Charles should not abide the Pope.

Let us create the contradictions of requirements.

RC-1 (requirement contradiction): If the crown is put on Charles' head by the Pope of Rome, Charles will become the king, but he will have to abide the Pope.

RC-2: If Charles himself puts crown on his head, he will not have to abide the Pope of Rome, yet he will not be the king.

Let us define the instrument. From the RC we can see that it is the crown. It must possess two characteristics – it must be put on both by the Pope and by Charles.

SC: The crown should be put on both by the Pope of Rome so that Charles would become the king and by Charles himself so that he should not abide the Pope of Rome.

The most suitable approach is "division in time". It is the Pope of Rome who starts to put on the crown, but Charles the Great finishes the procedure.

And during the ceremony Charles simply intercepted the crown from the Pope's hands and placed it on his head himself.

At the beginning it is possible to create tasks by using those in the exercise book. But later the teacher must create a catalogue of interesting tasks by using any available materials.

## Lesson 5. Perfect end result

When solving tasks, students offer very different solutions and they do not always understand why the teacher supports one solution, but not the other one.

For instance, a task concerning an oil exploration platform in the Arctic Ocean.

Oil fields are often located in the sea bottom. In order to pump oil, floating platforms are built and oil drilling towers are located on them. These platforms have powerful engines operating oil pumps. During winter, water on the ocean's surface freezes forming ice. As it is known, when freezing, the ice expands and thus breaks the base of the platform. The platform may slant or even sink.

How to preserve the platform during winter?

Student Denis offered to bombard the ice from a submarine that would be on duty near the platform during winter. In his turn, student Nikolay proposed to solve the task by placing the exhaust pipe of the platform engines into water. The hot exhaust gases will not let the water freeze. Yet Denis could not understand why his solution was worse than the one offered by Nikolay.

**Exercise 5.1. Compare answers**

The teacher should give any task to students and listen to answer variants of every student. The teacher should ask the students to tell why their solution is better than solutions of others.

This procedure should be repeated with several exercises and find out with children whether there is something in common in the principle of choosing the best solution? If students cannot understand it themselves, the teacher can ask them – is this so that usually the best solution is the one that introduces the smallest change in the system when compared to other solutions?

**Exercise 5.2. Write down the formulation of the PER**

If students agree, the teacher may offer them to write down the formulation of the perfect end result (PER):

The thing that we need must happen BY ITSELF in a way there are no changes in the system as far as it is possible.

## Lesson 6. Language use, terminology

In order students would be able to use language, not just to repeat it, they must learn not to perceive terms as an absolute truth and learn how to form their own terminology.

**Exercise 6.1. What questions could a house ask?**

Every student must imagine their own character, for instance, a cat, a robot, a house, a Stone Age human. After that they have to write the possible philosophical questions this character might ask. For instance, a house asks a philosophical question: how can we explain graffiti on walls? And we must think with what terms the character of every student could explain this philosophical question?

**Exercise 6.2. Creating your own terms**

Everyone thinks of their own – new – term, while others try to find out the meaning of this term using the "Yes – No" method.

**Exercise 6.3. An unknown animal and terminology used to describe this animal**

Imagine an unknown animal, think of its name and terminology that would explain its habits.

*Expected result:*

1) When students hear new terms, they form a new or replenish an already known model of notions;
2) A term is perceived as a temporary explanation of a particular situation, not as constant truth.

## Lesson 7. Catalogue

In order children could operate with not just one factor and draw conclusions from one-factor situations, they must learn how to form a catalogue.

**Exercise 7.1. Telling why people should visit a particular geographical object**

Every student is assign as the responsible for a particular geographical object, say, the Galapagos whirlpools, the volcano Etna, a giant sequoia, an iceberg in the Arctic Ocean. The task of each student is to prepare a story about their object and to persuade others to go on an excursion to their object.

*Expected result:*

In order to ensure a convincing story, students have to prepare several significant facts – arguments so that it would be interesting for others to listen, i.e. ability to operate with a great number of factors.

**Exercise 7.2. Comparison of geographical objects**

Compere one’s own geographical object with an object of the same kind, yet from a different place. For instance, what are differences between icebergs from different areas?

*Expected result:*

Children learn to compare and group the acquired knowledge (facts).

## Lesson 8. Qualities of a creative personality (CPQs)

Adopt those qualities of creative personalities that are required for a person to be able to take talented decisions.

**Exercise 8.1. Talented people and their achievements**

Read or listen to stories about childhood and achievements of talented people, for instance, Mozart, Faraday, Pascal, or Brunelleski. But the best solution would be to choose biographies of those talented people whose character coincides with students’ characters.

*Expected result:* Children compare their life with the life of a talented personality. In the ideal case children start wishing to emulate the talented person, but this will happen only if the student will admire their hero.

**Exercise 8.2. Contradictions that were solved by talented people**

Analyse contradictions that Mozart, Pascal, Brunelleski, or Faraday dealt with, but whose solution students are not aware of.

After learning about the life of a talented person, students should see how this person solved contradictions appearing in her life and activity. It is necessary to analyse and ask how students would behave if they were this person and what decisions they would make.

*Expected result:*

We form understanding why creative people have contradictions. Students gradually start to understand that it is necessary to solve a lot of problems in order to become loved by everyone.

# Experience in Schools of Estonia

**Maie Oppar, Astrid Org**

This chapter gives an overview of how exercises based on TRIZ method (Theory of Inventive Problem Solving) were tested in two Estonian primary schools. The schools that participated in this project were Parksepa High School and Rõuge Elementary School in Võru county, Estonia: All in all 121 students aged 7-13 and 11 teachers participated.

These were relatively small rural schools. Parksepa school has 321 and Rõuge school 162 students.

The sample included the students whose class teachers agreed to test TRIZ exercises – all in all 12 classes piloted. The exercises were solved in different subjects together with class teachers (in years 1-6 class teachers cover all subjects

In the 6th year of Parksepa school the teacher made exercises on a fixed day of the week in course of two months. This day was referred to as the day of talented thinking. Ms Ülle Noppel – the teacher of year 6 – carried out the exercises in smaller groups consisting of fast learners and slow learners. The results in these groups differed considerably.

The following will give an overview of the feedback collected from teachers about exercises (Chart 1).

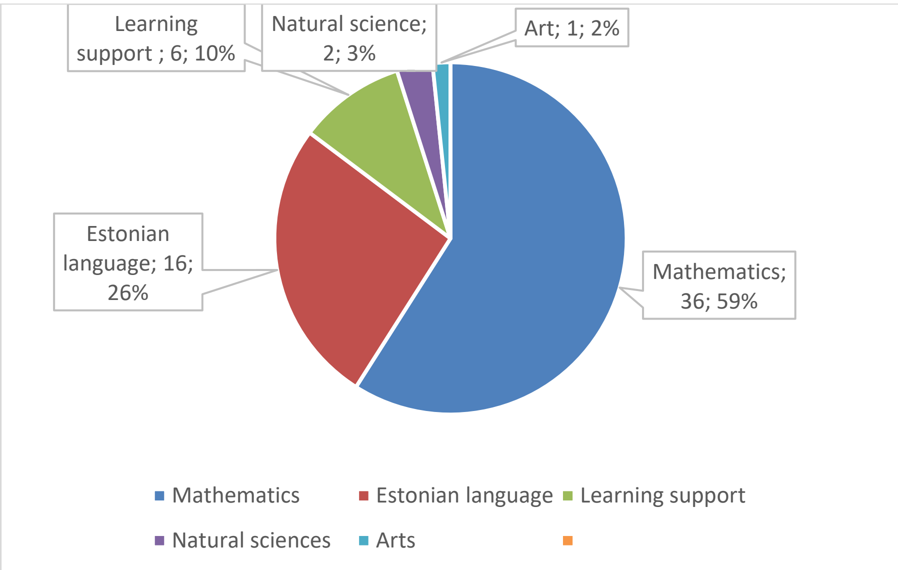



*Chart 1. Using the exercises in different subject lessons*

Most of the exercises were implemented during mathematics and the Estonian language classes. One teacher tried out the exercises in learning support classes the aim of which is to train student's attention, ability to concentrate and cognitive skills (perception, memory, thinking).

The exercises (Appendix 1) where structured. After testing the teacher filled in a feedback questionnaire (Appendix 2). The teachers were free in choice of exercises the purpose of which was to screen out the most applicable ones.  In the chart below we can see the teachers´ preferences.

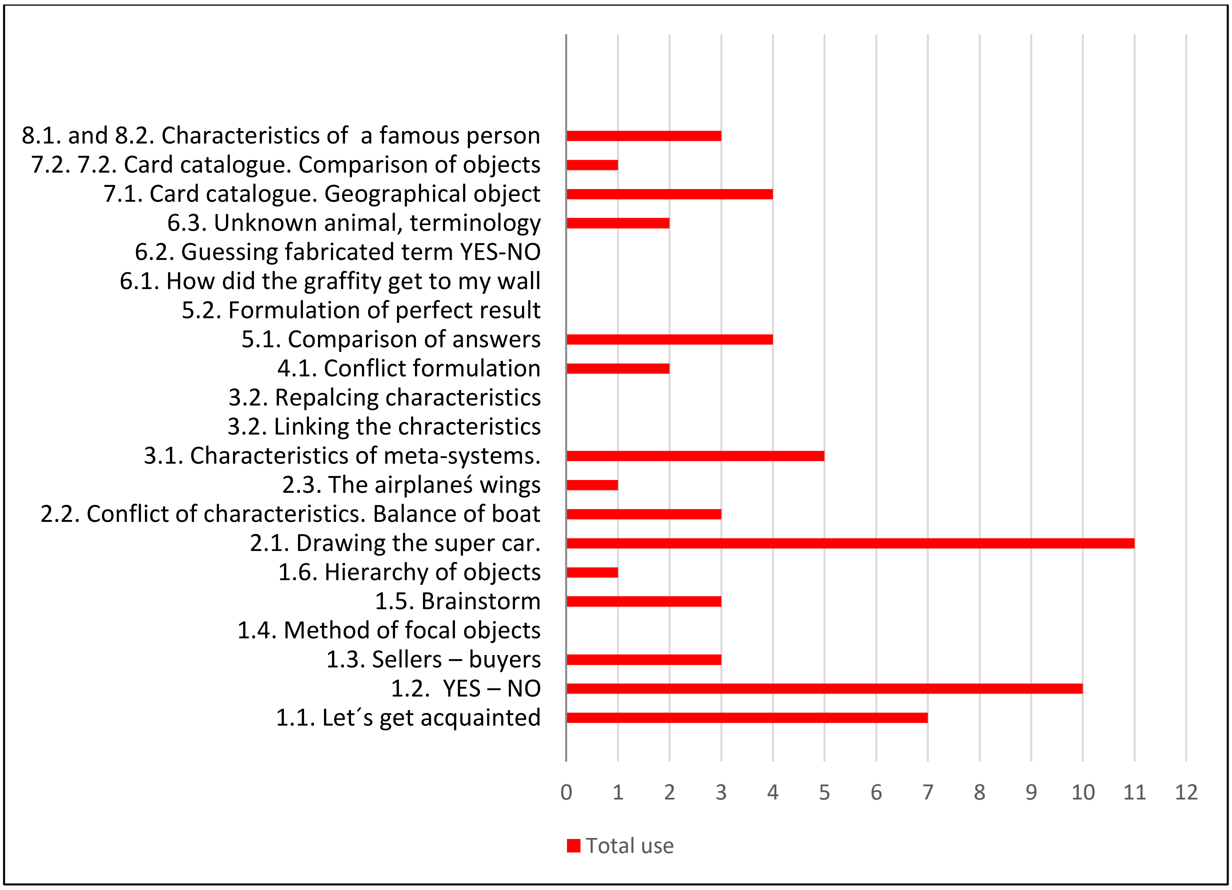



*Chart 2. Application of exercises by the teachers*

As we can see some exercises were not used. According to the teachers they were inappropriate for students’ age and/or previous knowledge base. In some cases the processes and the purpose of the exercise was unclear thus resulting in rejection. Exercises 8.1 and 8.2 were considered to be parts of one and the same exercise and were used together by the teachers.

The most popular exercises were suitable for children in different age groups. Also preference was given to the exercises that had more detailed and clear descriptions.

**The teachers´ assessments and suggestions.**

The teachers made their remarks after each exercise on the feedback questionnaire (Appendix 2). First they assessed effect of the exercises based on the criteria of the authors. They also gave feedback on how the exercises were perceived by the children and shared their experience on what should be taken in consideration when using them in classroom situation or individual work.

The following table reflects teachers´ feedback and suggestions to the exercises starting from the most frequently used exercises.

<table>
<tr><th>No and name of the exercise</th><th colspan="2">How the expected result was achieved</th><th>Comments to the achievement of the goal</th><th>Feed back to the process in classroom situation</th><th>Suggestion on alternatives or modification of the exercises</th></tr>
<tr><td rowspan="3">2.1. Conflict of characteristics. Drawing the super car.</td><td>Expected result was not achieved</td><td>0</td><td rowspan="3">The first result / goal was explained unclearly by the author.<br><br>The result was much worse when there were many girls in the classroom.</td><td rowspan="3">– Children need more time for drawing (20 min);<br>– In bigger class there is not enough time for all to introduce their super car.<br>– There are children who struggle to find good characteristics, they more easily found bad ones;<br>– Children copied ideas of classmates;<br>– Understanding good and bad – for example, one good characteristic was that the car could carry lots of weapons;<br>– Children were in difficulties</td><td rowspan="3">• Plan enough time for the exercise;<br>• Suggest alternative exercises to meet different interests in the class;<br>• Authors should describe in the exercise how to help the child and how much should be helped if the child lacks ideas.</td></tr>
<tr><td>Expected result was partly achieved</td><td>5</td></tr>
<tr><td>The result was achieved as expected</td><td>6</td></tr>
</table>

| | | | | | |
|---|---|---|---|---|---|
| | The result was better than expected or surprising | 0 | | to describe the characteristic in one word (generalisation);<br>– The results of the girls were no as good as those of boys;<br>+ Children noticed that one and the same characteristic could be both good and bad;<br>+ The exercise was very effective of children who have activity-attention disorder or autistic traits. | |
| **1.2. YES - NO** | Expected result was not achieved | 0 | - | – Children did not listen to their peers which resulted in repetition of questions;<br>– Children have insufficient knowledge (they do not know odd numbers and divisibility with three);<br>– With a bigger group all children cannot answer; | • The right answer should correspond to the age and development of the children lapse;<br>• The best group size is 8 (+/- 2), in a bigger group subgroups of 2-3 may be formed so that group members ask questions from each other |
| | Expected result was partly achieved | 1 | | | |

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| | The result was achieved as expected | 7 | | – In case of children with learning difficulties it took several games until they understood how to ask a question; | |
| | The result was better than expected or surprising | 2 | | + Children grasped quickly the essence of the exercise (they had played games with yes and no questions before);<br>+ Children could make up questions in cooperation with their call mates;<br>+ Children grasped quickly the system that questions should start from general and go to specific ones. | |
| **1.1. Let´s get acquainted** | Expected result was not achieved | 1 | The results were not achieved by a mentally challenged child. | – Did not work in face-to-face situation;<br>– One child started to ridicule classmate´s choice of profession (intervention took time and distracted children´s thoughts for some time); | • The exercise works better when sitting in a circle;<br>• To make sure that everybody gets time for, a talking ball or talking stick could be used to pass the word. |
| | Expected result was partly achieved | 0 | | | |
| | The result was achieved as expected | 6 | | | |

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| | The result was better than expected or surprising | 0 | | + Good review was given of the problems that may appear with the desired profession;<br>+ Children that knew each other well found out new information about their class mate;<br>+ Children were excited while waiting their turn. | |
| **3.1. Contradictions meta-systems. Characteristics of meta-systems.** | Expected result was not achieved | 1 | Mentally challenged children did not achieve the result as the exercise was beyond their capability | + Children were excited and suggested interesting solutions;<br>+ Children were eager to present their own work;<br>– Some children could not think of any solutions;<br>– The exercise did not contain description of the expected result (how to assess the result). | • The exercise works better when sitting in a circle;<br>• The exercise could be combined with writing a fantast story;<br>• The instruction of the exercise could be more detailed. |
| | Expected result was partly achieved | 1 | | | |
| | The result was achieved as expected | 0 | | | |
| | The result was better than expected or surprising | 3 | | | |
| **5.1. Perfect result. Comparison of** | Expected result was not achieved | 0 | The instructions lacked well | + The children recalled and used previously obtained | • - |

| | | | | | |
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| **answers.** | Expected result was partly achieved | 0 | described goals (expected results) | skills;<br>+ The answers were rich in fantasy. | |
| | The result was achieved as expected | 4 | | | |
| | The result was better than expected or surprising | 0 | | | |
| **7.1. Card catalogue. Geographical object** | Expected result was not achieved | 0 | - | + ICT means can be used while solving the exercise;<br>+ Presentations enabled to practice their public speaking skills;<br>+ Children obtained lots of new knowledge;<br>– Often children collected random facts;<br>– Too challenging for children with learning difficulties. | • To use ICT for data search;<br>• To choose an object that corresponds to the children's level (for example, the 1st year students get a letter and collect as many words starting with this letter as possible and make up a card catalogue. Then explain to others why it was good to work with this letter). |
| | Expected result was partly achieved | 1 | | | |
| | The result was achieved as expected | 1 | | | |
| | The result was better than expected or surprising | 2 | | | |
| **1.3. Sellers – buyers** | Expected result was not achieved | 0 | | – Role of the teacher is crucial (need for support);<br>+ Children´s creative thinking, boundless comments and | • Use different rooms during the exercise;<br>• Sit in a circle. |
| | Expected result was partly achieved | 0 | | | |

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| | The result was achieved as expected | 2 | | absurd arguments led to exciting results. | |
| | The result was better than expected or surprising | 1 | | | |
| **1.5 Brainstorm** | Expected result was not achieved | 0 | - | + It was surprising that usually timid children demonstrated fantasy and pragmatic action;<br>+ Leadership skills were revealed among children that had previously not showed any;<br>+ Children quickly adapter to the new role. | • - |
| | Expected result was partly achieved | 0 | | | |
| | The result was achieved as expected | 2 | | | |
| | The result was better than expected or surprising | 1 | | | |
| **2.2. Conflict of characteristics** | Expected result was not achieved | 0 | The author´s instructions lacked well described goals (expected results) | + Children suggested interesting problem solutions (e.g. on the way back a passenger will be taken on);<br>– There were no defined goals. | • Specify the expected results and process of the exercise |
| | Expected result was partly achieved | 0 | | | |
| | The result was achieved as expected | 2 | | | |
| | The result was better than expected or surprising | 1 | | | |

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| **8.1. and 8.2. Characteristics of a creative person** | Expected result was not achieved | 0 | - | - | • To choose personalities that are familiar to children (authors of children books and pop-singers etc.) |
| | Expected result was partly achieved | 0 | | | |
| | The result was achieved as expected | 3 | | | |
| | The result was better than expected or surprising | 0 | | | |
| **4.1. Conflict formulation** | Expected result was not achieved | 0 | The author´s instructions lacked well described goals (expected results) | – Boys were more active than girls;<br>– Children did not listen to the teacher´s explanatory historic background;<br>+ Lots of original solutions were produced. | • - |
| | Expected result was partly achieved | 2 | | | |
| | The result was achieved as expected | 0 | | | |
| | The result was better than expected or surprising | 0 | | | |
| **6.3. Using the language, terminology** | Expected result was not achieved | 0 | - | + The ideas of classmates were creatively used;<br>+ Some children used body parts of several animals in | • Add drawing |
| | Expected result was partly achieved | 0 | | | |

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|---|---|---|---|---|---|
| | The result was achieved as expected | 2 | | creating a new animal. | |
| | The result was better than expected or surprising | 0 | | | |
| **7.2. Card catalogue** | Expected result was not achieved | 0 | - | + Children created lots of new exciting connections during the game. | |
| | Expected result was partly achieved | 0 | | | |
| | The result was achieved as expected | 0 | | | |
| | The result was better than expected or surprising | 1 | | | |
| **2.3. Conflict of characteristics. The airplane.** | Expected result was not achieved | 0 | The author´s instructions lacked well described goals (expected results) | – At the beginning children could not follow the exercise;<br>+ Eventually children tested many different solutions and could also craft manually | • - |
| | Expected result was partly achieved | 1 | | | |
| | The result was achieved as expected | 0 | | | |
| | The result was better than expected or surprising | 0 | | | |

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| **1.6. Hierarchy of objects** | Expected result was not achieved | 0 | - | – The exercise was not feasible for children. The teacher had to provide too much support. | • Word cards could be used |
| | Expected result was partly achieved | 1 | | | |
| | The result was achieved as expected | 0 | | | |
| | The result was better than expected or surprising | 0 | | | |

## Comparison groups

Notes were taken in parallel while testing exercises in the 5th year mathematics lesson with two groups – slow learners and fast learners. It appeared that results varied depending on the speed of thinking. Teacher´s remarks:

| Fast group (year 5) | Slow group (year 5) |
|---|---|
| – Listened attentively to the instructions | – Instructions took much time and some needed individual coaching |
| – Children grasped quickly the essence of the exercise | – Children got tired and could not follow the partner; thus started to ignore the instructions. |
| – In problem solving exercises the boys were more active and their solutions were down to earth | – Problem solving exercises gave unrealistic solutions |
| – Results were good when working in a circle | – Sitting in a circle caused confusion |
| – Emotions were under control | – Children were emotional, cheerful and fantasising |

## Conclusion

Exercises based on the TRIZ methodology demonstrated that children´s delight in work is caused by action itself and using their abilities rather than pay-off in form of mark, praise of fame. In Estonian schools active methods like group work, case study, discussion, role play etc. are used quite often. The TRIZ method is one of them helping to enrich the teachers´ tool kit of active methods. TRIZ exercises help to guide the students in finding creative solutions to feasible problems and experience the benefits of working together.

# Expierence in Schools of Latvia

**Sanita Cirse, Inese Soma, Sandra Fismeistare, Sarmite Meldere**

**Introduction.**

As you become familiar with the Theory of talented thinking, it becomes clear that it is not just the next trendy method that teachers must rush to learn in order for them to be considered innovative and modern educators. Although difficult, talented thinking is a way of living and working throughout one's whole life. It is not easy to create or develop something new, as there is no standard to follow or to draw comparisons with to demonstrate one's success in an engaging manner. Therefore it is safe to say that the teachers involved in the project are brave, ready for new challenges and are not afraid to make mistakes.

**Participants of the project.**

The image provides an overview of the participants involved in the project.

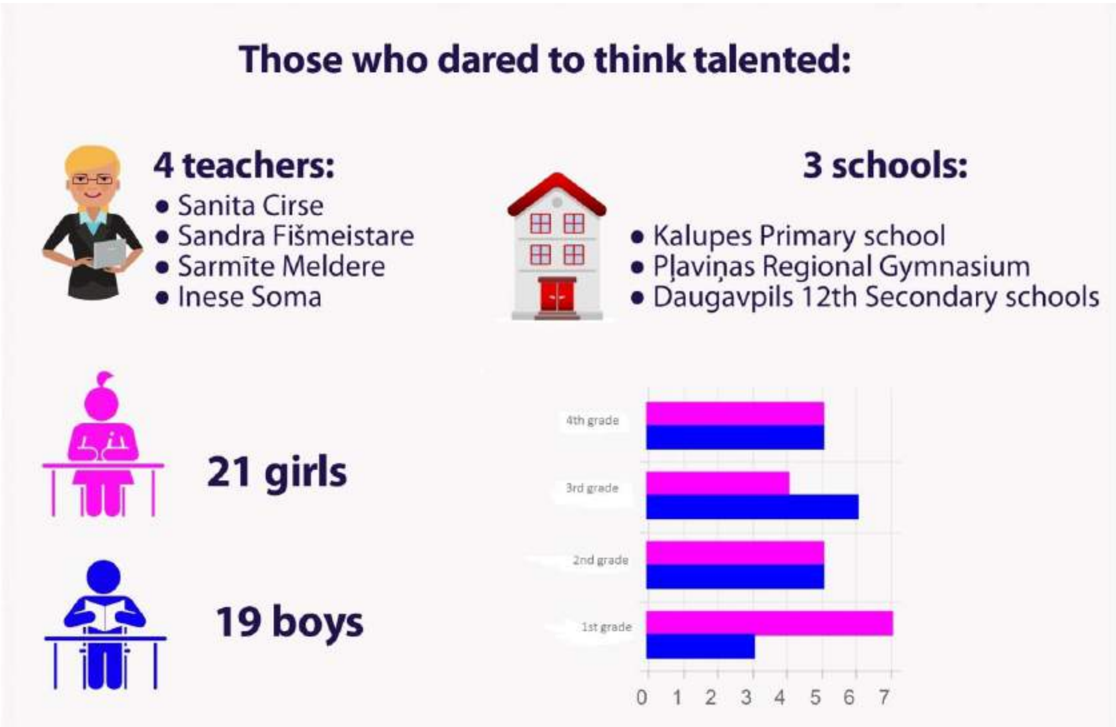


Image 1

**Experience in developing talented thinking.**

The teachers were offered a set of exercises to be used in trial classes for developing traits of talented thinking. All teachers organised their work as extra-curricular activities. Expected result: teachers form their exercises and methodological guidelines for the development of talented thinking.

The following table contains a summary on the progress of the exercises being tested with notes from the teachers.

| **Generalisation** | |
|---|---|
| Exercise 1 | Game "Yes-No" |
| Rules of the exercise | For example, one has to guess an imagined number from 1 to 100. Prior to that, the teacher must calculate what the minimum number of questions required for acquiring the answer is. The closer the number of questions asked to the minimum amount, the better the result. For example, the imagined number could be 46. The interval may be consecutively divided by 2 with the help of questions. Thus, the minimum number of questions could be 7. The level of thinking is considered to be high if 7-9 questions have been asked, and low if the number of questions asked is much greater.<br><br>An exercise of such a type is prepared by the teacher. Later on it can also be done by the students themselves according to the example provided. |
| Teacher notes | At first, a chaotic guessing of numbers takes place and the same questions are repeated over and over again. This should be allowed at the beginning. After showing the students that it is possible to reach the solution faster and more purposefully by reducing the interval of the number to be guessed, the students gained an insight into the advantages of a systemic approach.<br><br>The students enjoyed variations of the game where they had to guess letters, fruits and vegetables, as well as animals. Thus, by practicing the skill of generalisation, the students also learnt about |

| | |
|---|---|
| | consonants and vowels, classification of fruits and animals, etc. in a playful manner. |
| Exercise 2 | Characteristics of an object |
| Rules of the exercise | Students are given a group of drawings of randomly chosen objects. The drawings must be selected according to the principle of maximum randomness, in order for them not to form any patterns. Then it has to be explained according to which parameters each of the objects differ from the other objects of the group.<br><br>For example, the following group is provided: a ball, a flower, a snake, a kitten, an elephant.<br><br>The ball is different, as it is the only thing that is not alive.<br><br>The flower is different, as it is the only thing that smells nice.<br><br>The snake is different, as it is the only thing that is venomous.<br><br>The kitten is different, as it is the only thing that is fluffy.<br><br>The elephant is different, as it is the only large thing.<br><br>The level is considered to be high if the student is able to differentiate between the objects of the group easily and quickly. The level is considered to be low if the student is only able to identify the difference between one or two objects. The exercise is prepared by the teacher. |
| Teacher notes | The students are able to differentiate between the objects of the group quite easily, as most of them usually start with the easiest objects.<br><br>The following variations of the game were offered: 1) the student drew one word in a lottery, and the following students had to find similarities with the previous object; 2) game “Can I Come Into the House?” The house “includes” a student who may freely choose an object or a phenomenon, and the next student may only “enter” if a similarity is found with the respective word; 3) names of the objects are used in the game instead of their drawings. It allows the |

| | |
|---|---|
| | list of features characteristic to the object to be extended with dimensions such as sound, pace, material, etc. |
| Exercise 3 | Game “Sellers-Buyers” |
| Rules of the exercise | Students are divided into two groups. The teacher names each group after an animal, a profession or something similar. Each group thinks of an object that it would like to “sell” to the other group, but the respective object has to be one that is absolutely unnecessary to the other group. For example, a group named “wolves” may sell meat to a group named “cows”. The other group has to think of a situation, in which they would purchase the object offered by the first group. For example, cows could use the meat as ear plugs during sleep. The first group must ask "yes-no" questions in order to guess the imagined use for the object. Two types of skills are assessed during the game “Sellers-Buyers” – the capability to ask generalised questions and the ability to use objects in abnormal situations. If more than 5 questions are required for guessing the manner in which the respective object is applied, then it is obviously used in a way that is not typical.<br><br>When trying to solve such difficult puzzles, the first questions that are asked should be more general.<br><br>Will the meat be used at home? – Yes<br><br>Will the meat be used for one’s own needs? – Yes<br><br>Will the meat be used for gastronomic purposes? – No<br><br>Will the meat be used as bait? – No<br><br>Will the meat be used for personal convenience? – Yes<br><br>Will the meat be used on one’s own body? – Yes<br><br>Will the meat be used for improving one’s health? – No<br><br>Will the meat be used as a plug? – Yes<br><br>Will the meat be plugged into one’s nose? – No |

| | |
|---|---|
| | Will the meat be plugged into one's ears? – Yes<br><br>The level is considered to be high if the respective object is used in a manner that is very untypical and if 10 questions are asked. The level is considered to be low if a lot more than 10 questions are asked.<br><br>Students prepare the exercise for the students of the other group. |
| Teacher notes | At first, students thought of standard situations, thus it was easy to guess the conditions. The students came up with non-traditional uses after the game.<br><br>As in the first exercise, guessing is done during the game and no generalised questions are asked.<br><br>Some of the students got carried away with the game and also played it during their spare time. |
| Exercise 4 | Method of focal objects |
| Rules of the exercise | The method of focal objects works as follows:<br><br>a) the students are offered an object chosen by the teacher.<br><br>b) students themselves choose case words (for example, from a randomly opened page of the dictionary) that will describe the objects.<br><br>c) the students form a list of features for each of the random objects.<br><br>d) students transfer the features of the random objects to the target object one by one and try to identify what new interesting object may form.<br><br>e) students choose the most striking and unexpected result.<br><br>The level is considered to be high if the invented object is fundamentally different from the prototype and possesses outstanding new features in comparison to those of the prototype. The level is considered to be low if the invented object is |

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| | commonplace, does not differ a lot from the prototype and does not possess any new traits. |
| Teacher notes | Most of the students added another object to the given one instead of the features of the object. It is necessary to determine the features of objects in order to facilitate the understanding of this method. It is also preferable to display objects in which the respective method is used, for example, flip-up sunglasses (feature of a door – to open). |
| Creation of objects or systems by using a hierarchy of systems | |
| Exercise 1 | |
| | A freely chosen object that is well known to the children is given. One has to name its sub-systems, its anti-system according to the determined function or feature and several supra-systems.<br>For example: A desk is given.<br>A desk has the following sub-systems:<br>Legs, surface, drawers, leg folds, etc.<br>The anti-system of a desk according to the characteristic “wide” is a string (as the anti-characteristic of “wide” is “narrow”).<br>A desk has the following supra-systems:<br>Classroom furniture, row of tables in the canteen, a game (one can hide under the desk), a weapon (the desk may be thrown onto another person), food (if it is made of edible materials).<br>The level is considered to be high if the student manages to name all of the sub-systems, several supra-systems, as well as not only the existing but also possible anti-systems according to a parameter that is not obvious. The level is considered to be low if the student names one or two sub-systems, supra-systems and an anti-system according to an obvious parameter. |

<table>
<tr><td>Teacher notes</td><td>When having a lack of generalising skills, it is most difficult to find supra-systems. Sub-systems are named easier if the object is well known and visible. Several children enjoyed looking for anti-systems.<br><br>It is possible to train the skill of seeing a hierarchy of systems to a high level by converting the exercise into a spare time game.</td></tr>
<tr><td colspan="2" align="center">Ideal system</td></tr>
<tr><td>Exercise 1</td><td>The children are given a well-known function. An ideal system that performs the respective function has to be provided.<br><br>For example: Fish in the pool may be counted in one of the following ways:<br><br>1. By making a robot that counts fish.<br><br>2. By taking a picture of the pool and counting the fish according to the photo.<br><br>3. By blocking off the pool and leaving a small opening through which only one fish can swim at a time. Throw aromatic bait into the empty part. The fish will swim there themselves and it will be easy to count them.<br><br>4. By asking the seller how many fish he or she sold to the pool.<br><br>High level – making use of the tools at one’s disposal (2., 3.). Low level – making use of non-relatable items (1., special tool, magic wand, killing all of the fish and then counting them, etc.). In some cases, another level – very high – may be introduced if the students manage to name a condition when there is no need for a function (4.).</td></tr>
<tr><td>Teacher notes</td><td>The answers of the students were mostly closer to the first solution, i.e. inventing a robot, counting machines etc. The students who swim or have experience in fishing expressed proposals of a high level more often.<br><br>It was interesting that there were students who questioned the</td></tr>
</table>

| | |
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| | necessity of the action described in the exercise. The exercise could be formulated more specifically, be better linked with real life or the real need for the exercise could be showed after its solving. For example, counting of fish in the zoo. |
| Catalogues (Card index). | |
| Exercise 1 | Creating a description of a phenomenon by using the personal catalogue. |
| | Each student is assigned an object. For example, Niagara Falls, Mount Etna, Galapagos Islands, coral reefs, etc. The student has to form a story about the respective object that would make all of the others want to go on an excursion to the respective place. The exercise is given in the form of homework, but, when assigning an object to a student, it is necessary to check how much he or she knows about it. It is required to find out whether the student knows anything about the object beforehand. This is required for it to be possible to compare the students during the next lesson, when they present their final works. It will then be possible to see what the student had known before the exercise and what he or she found out by the moment of presenting it. The more arguments a student has, the better the result of the assignment.<br><br>The level is considered to be high if the student manages to tell five to ten previously unknown facts about the object. The level is considered to be low if the student fails to tell anything or almost anything new about the respective object. |
| Teacher notes | It was difficult for the students to find information, as some of them were not able to read well enough, whereas others had never worked with encyclopaedias or the internet before. Thus, the results may be improved by mastering the techniques of searching for information.<br><br>It was offered to one of the target audiences to start forming a story about objects to which they have been on excursions by searching |

| | |
|---|---|
| | for a suitable object later on. For example, the highest peak of Latvia – Gaiziņkalns, highest peak of the world – Mount Everest, the longest river of Latvia – the River Daugava, and the longest river in the world – the Nile, etc. |
| Conflict resolution | |
| Exercise 1 | The students are given a problem, the solution to which they do not know. They must analyse the problem and provide a solution by using conflict resolution methods.<br><br>**For example:** In the year 332 BC, construction of the Lighthouse of Alexandria was started and it was completed in 283 BC, when Egypt was ruled by Ptolemy II. The lighthouse was constructed by Sostratus of Cnidus. He was very proud of his construction and wanted people to remember his work. However, at the time it was customary to write the names of rulers on buildings, i.e. the name of Ptolemy. If Sostratus were to write his own name of the building instead of the ruler's one, he would be beheaded. But if he did not write his name on the lighthouse, no one would ever know that it was him who constructed it. What should Sostratus do?<br><br>It is possible to reach **a high score** if requirement contradictions are formed (**RC-1** and **RC-2**), an **instrument** with two opposite qualities and a quality contradiction (**QC**) is selected, and a proper technique and a solution is found.<br><br>In turn, **a low score** is attained if the students start guessing the answer straight away.<br><br>**RC-1:** If Sostratus will engrave his name on the lighthouse, everyone will remember his name but Ptolemy will punish him with death.<br><br>**RC-2:** If Ptolemy's name will be engraved, Sostratus will not be punished but no one will remember his name.<br><br>**Instrument** – the name (Sostratus, Ptolemy). |

| | |
|---|---|
| | **QC:** The name of the ruler should be engraved on the lighthouse so that he would not punish Sostratus, and there should also be the name of Sostratus so that people would know that he built the lighthouse.<br><br>The appropriate technique – **splitting time**. First, the name of Ptolemy is on the lighthouse, but later on the name of Sostratus appears in its place.<br><br>**Control answer:** Sostratus wrote his name on the lighthouse, put plaster on it, and wrote the name of Ptolemy on top of it. The plaster came off with time, revealing the name of Sostratus. |
| Teacher notes | The students offered various ideas, and there were also options that were similar to the control answer.<br><br>However, the answers were more like guesses, and the conflict resolution method was not applied. By solving more tasks of such a type, the conflict resolution method could be easily mastered. |

## Teacher creativity

### Sanita Cirse

By considering the analysis of the trial classes and one's own pedagogical experience, it was expected that as a result the teachers would develop methodological guidelines for facilitating talented thinking.

"What does it mean to think?", "Do we have to think all the time?", "What should we think about?"

I asked these and other initiating questions to children aged 7-10, and I received the following answers:

- If you think about something, you are never bored.
- One can come up with smart things when thinking.
- One has to think before acting.

- If a person is bored, he or she may think of something to think about.
- One has to think in order to live.
- One can come up with beautiful and necessary things when thinking.

The responses provided by the children show that they are well aware of the importance of the thinking process. The very fact that a child understands the value of thinking is the most important self-motivational factor in the development of one's thinking skills. Children feel the need to understand the world; they possess natural curiosity about what takes place around them.

Thinking includes a critical, as well as a creative aspect. Both are used in reasoning and in the creation of ideas, therefore it is important for the youngest students to learn how to think flexibly, think brave and think smart.

I believe that the following things have to be taken into account when organising classes for children:

- Organising the thinking process in a way that it possesses a value-orientated character.
- Encouraging one's imagination, a stimulating environment and space for facilitating the thinking process.
- The thinking process may not be limited by time or a competitive atmosphere.
- When organising the thinking process, it is important to respect one's desire to act individually or in a team.
- Children take part as long as they want to do so.

The easiest and most efficient way for developing thinking is playable exercises.

An exercise sounds serious and important, whereas playing sounds free and relaxed. In order to reach a successful outcome, there is a need for a friendly atmosphere that encourages one to act responsibly.

**Exercise 1 Pyramid**

All of us have come across multicoloured dice, hats of chimney-sweeps and fairies, crystal balls and card houses in the world of games and tales. These objects are mainly based on geometric shapes such as cubes, cylinders, cones, spheres and pyramids. It is the pyramid that has seemed a stable "building" since ancient times. Thus, the construction of a pyramid is widely used nowadays if order and stability is needed. For example, the shape of a pyramid may be used to display what can be afforded and what should be limited when pursuing a healthy lifestyle.

Images provided – food pyramid and physical activity pyramid (Image 2).



**HEALTHY EATING PYRAMID**

(eating healthy with pleasure)

5% - fats, sweets

20% - milk and dairy products;

meat, eggs, fish

35% - vegetables;

fruits, berries

40% - bread, cereals, pasta, rice, porridges, potatoes, etc.

**PHYSICAL ACTIVITY PYRAMID**

**Moderate sitting**

- video games
- TV watching

**2-3 TIMES A WEEK**

Spare time activities (golf, bowling, gardening)

Stretching / strength exercises (abdominal exercises, doing push-ups, weightlifting)

**3-5 TIMES A WEEK**

Activities while in nature (long walks, cycling, swimming)

Entertaining sports (tennis, squash, basketball)

**EVERY DAY**

(walk as much as possible,

go on walks with your dog,

use stairs instead of the elevator,

park your car further away and walk)

**Move more! Sit less!**

Image 2

The perception of the task and the thinking process may be directed in the following order:

1. example;
2. guided practice;
3. independent practice;
4. independent use.

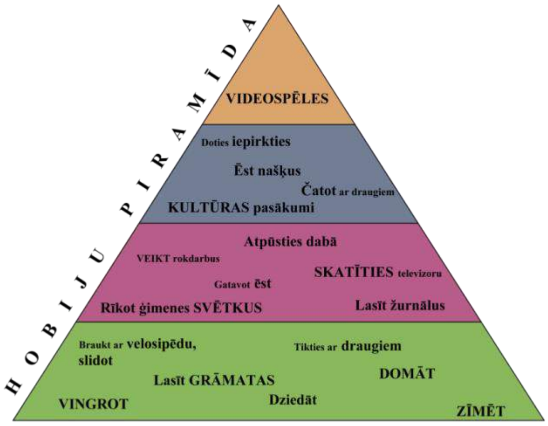
First, children become acquainted with the information, compare it, find similarities and differences, analyse it.

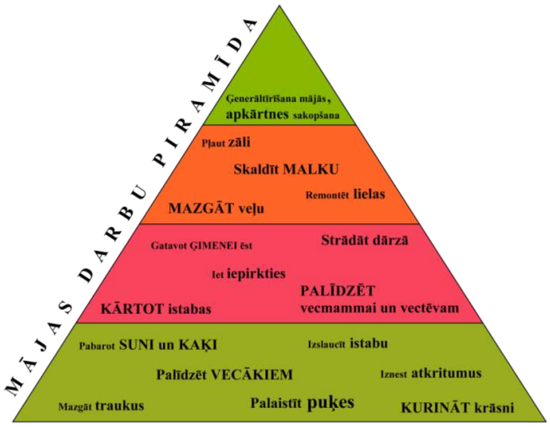
Attention must be given to the form in which the information is provided. The younger school-age children should be shown a model of a pyramid, in order for them to be able to understand that products or activities are arranged on shelves of different sizes depending on how much or little and how often or rarely they are needed.

The children practice making the play pyramid together, as well as suggest what other types of pyramids could be made.

Pyramids made by the children:

Hobby pyramid (they differ for girls and boys).




| **HOBBY PYRAMID** | **DOMESTIC WORK PYRAMID** |
|---|---|
| VIDEO GAMES | General cleaning at home, tidying up surroundings |
| Going shopping; Eating sweets; Chatting with friends; CULTURE events | Mowing the lawn; Chopping WOOD; WASHING clothes, Repairing things |
| Spending time in nature; DOING needlework; WATCHING TV; cooking; Organising family CELEBRATIONS; Reading magazines | Cooking for the FAMILY; Working in the garden; Going shopping; HELPING grandmother and grandfather; CLEANING rooms |
| Riding a bike, ice-skating; Meeting friends; Reading BOOKS; THINKING; EXERCISING; Singing; DRAWING | Feeding the DOG and the CAT; Sweeping the room; Helping PARENTS; Taking out the rubbish; Washing the dishes; Watering the flowers; HEATING the stove |

Image 3

These pyramids serve as great examples of how children could create their own pyramids after evaluating the already existing ones, thus finding out new information, and, possibly, starting to think more about setting their priorities and using their time more rationally. The reason why it is important to set one's priorities is that children are often not able to differentiate between their needs and preferences, therefore it is difficult to balance their time properly for various activities.

### Exercise 2 The most valuable

Regardless of whether it is big or small, new or old, whether it is a skyscraper or a tiny ant, everything possesses a certain value, as there is a need for everything in life.

We recognise all things, phenomena, processes, etc. by calling them by their names. The present exercise includes the opposite – imagining, appreciating and thinking deeper about the respective thing, phenomenon or process.

1. The children randomly select 4 words.
2. The children have to choose the most valuable word of the four according to their thoughts and justify their choice.

Another option: children choose the most valuable word in their word chain but do not reveal it to the others, instead they just call out the words that are required for guessing the respective word. The children assess their answers and compare them to the results of the author of the invented words.

Examples from the children:

A dog, a glove, dancing, a computer.

The most valuable one is the dog, as it is a living creature, it feels pain. It is the guard of the house, it helps people, it is a loyal “friend”.

Berries, a mirror, a key, a table.

The most valuable of all is the table. A table is irreplaceable, as it performs many functions – food is prepared on it, people eat, read, write and sew sitting next to it, discussions take place at it, it has been necessary for a very long time. It is a symbol of family unity.

Just as with any exercise – the present one may also be altered according to the preferences of the teacher or children:

1. One can try and see what is most valuable about every word.
2. One can try to think of a word that is more valuable than the present one.
3. One can try to line the words up according to their value.

All answers are correct in this exercise. The most important thing is for the child to justify his or her opinion, listen to the answers of others, thus gaining a positive experience.

**Exercise 3 Bridge**

Bridges have various structures and they are made of different materials, however, they all have the same goal – to connect. A bridge is a link between shores, between countries, between hearts. If there were no bridges, there would be no movement, no understanding, no joy.

Words can also serve as shores, as well as bridges. The strongest bridge will be the one that has the best connection with the words of the shores.

1. The children choose two random words.
2. They must think of a "bridge" word that would be linked with both "shore" words.

Examples from the children:

Milk and firewood.

The bridge word is 'energy', as one receives energy when drinking milk, but energy is lost when chopping wood.

The exercise may be diversified by asking the children to think of a "bridge" name not only for their own "shores" but also those of others, or by asking them to try and guess the reason why the author has chosen the specific "bridge" word.

Examples from the children:

Watering-can and a cloud.

Bridge word – 'water',

- since it may be poured out of a watering-can and it also rains from clouds.
- since an aluminium watering-can, a cloud and dirty water have the same greyish colour.

Computer and bread.

The bridge word is ‘necessity’, as a computer is necessary for acquiring information, paying bills, communicating, whereas bread is necessary for one’s diet and is a valuable source of nutrients.

The bridge word is ‘table’, as it is more convenient to use both if one is sitting at a table.

The bridge word is ‘sides’, as both of them have a top and a bottom, and it is important for them to be placed properly.

The youngest primary school-aged children may create a drawing, as this can make the activity more exciting, develop their imagination and strengthen the thinking process. In turn, older children may form a bridge of two or even three words.

**Exercise 4 Friends**

Why are people happy, smiling and cheerful? Because they have friends and they are the friends of someone. Friends help each other, talk about their sorrows, give advice, share with joy, go for visits. It is great to have many friends. Words can also be friends. The friendship of words helps in understanding one another.

1. The exercise is to be performed on a piece of paper, because it is important for it to be graphic.
2. The children choose random words and write them down on the right and left sides of the paper (Image 4).
3. Arrows are then drawn from the words to the middle of the paper and a “group of friends” has to be thought of by writing it down opposite the arrows. Two columns of words are then formed. It is recommended for each word to have the same amount of “friends”. The words “befriend” one another as if they have some sort of a link between them.
4. The children try to find pairs of “friends” in columns of words.
5. If a link is not found between certain words, they then form the basis for searching for a “group of friends”.

Different variations can be used for the exercise. If a connection cannot be found while looking for pairs and there are several “lonely” words left, then the “group of friends" may be supplemented with a specific aim – thinking of such words that would make everyone "become friends".

When creating the scheme, the child must work out himself or herself why the respective words have been chosen. However, in order to check the child's understanding and enrich the experience of other children, the teacher may ask the child to read and explain the selection of the words, and, perhaps, other children will add other words, thus formulating the best possible solution.

Examples from the children:

A hare has light brown fur that changes colour as the winter arrives.

A chimney serves to vent smoke, as the firewood burns, giving warmth to the house.

Fur helps to stay warm during the winter, as it is thick.

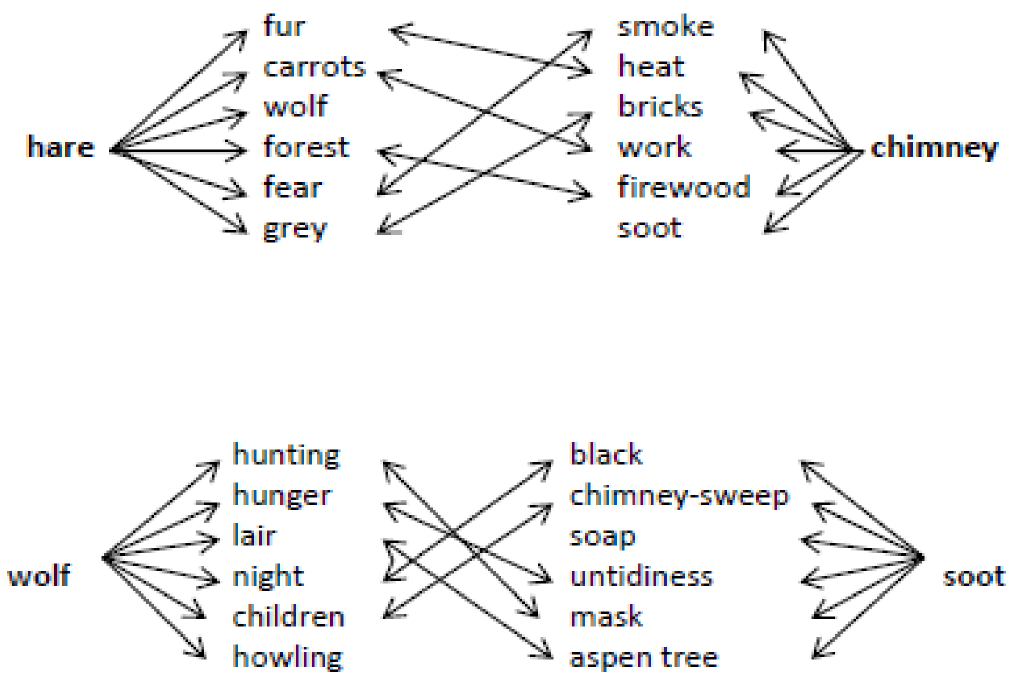



Image 4

**Exercise 5 Dominos**

Everyone has played dominos. Image dominos, animal dominos, number dominos, dominos with ethnographic signs, maths dominos. But what about random word dominos? Is there such a thing? There is now.

1. Children think of random words or select them from a book, write them down on pieces of paper and randomly deal them in pairs.
2. Then domino cards have to be created.

| | | | | | |
|---|---|---|---|---|---|
| a sock | a day | a king | wisdom | help | anger |
| a dog | a window | a beggar | a scandal | garlic | a fly |
| a night | a mirror | a smile | a crash | a bowl | an egg |
| rain | joy | a tooth | a classroom | elections | a ghost |
| a lightbulb | a ship | a stomach | North | a slipper | boxing |
| a book | a rag | a shadow | a hospital | smoke | unrest |
| fingers | a house | laughter | an invoice | the mind | a line |
| a list | feet | pain | a sandwich | a pillow | a doctor |
| a blanket | shoes | hair | appetite | a fairy | peace |
| porridge | a nest | a phone | a swing | beads | a forest |
| a mouse | a pocket | salt | health | a driver | a star |
| eyes | a ticket | money | water | clouds | a mobile phone |

| | | | | | |
|---|---|---|---|---|---|
| mud | a car | a dance | sleep | speed | butter |
| electricity | scissors | crisps | a pencil | a hedgehog | Santa Claus |
| straw | a runner | ice-cream | wind | a gnome | bread |

The game of dominos has the following aim: as one places one word next to another one, a connection between them has to be found and it has to be explained in one sentence.

The children may agree on the rules of the game, as they can be diversified depending on the age of the children, as well as frequency of playing. In the simplest version of the game all children have the cards in their hands and they may choose the most suitable words by forming sentences that are not connected to the previous ones. A more complex version – everyone chooses one card from a stack. At the same time a reason for the connection has to be found by taking into account what others have said before, i.e., all children form a joint story. The children may choose one of the four pairs of words. The exercise requires the ability to concentrate, as well as act and make decisions quickly.

Examples from the children:

| | | | | | |
|---|---|---|---|---|---|
| fingers | a house | laughter | an invoice | the mind | a line |

When there are guests at the house, there is a lot of joy and laughter can be heard. When an invoice arrives, one has to think with his or her mind about spending less money. When one has to wait in a long line, it is possible to exercise one's fingers in various ways, so that it is less boring.

| | | | | | |
|---|---|---|---|---|---|
| electricity | scissors | crisps | a pencil | a hedgehog | Santa Claus |

It is easiest to open a bag of crisps with scissors. One cannot open bags with a pencil, but it is possible to draw a beautiful hedgehog with it. When hedgehogs go into winter sleep, Santa Claus comes home, where Christmas trees are adorned with electric lightbulbs.

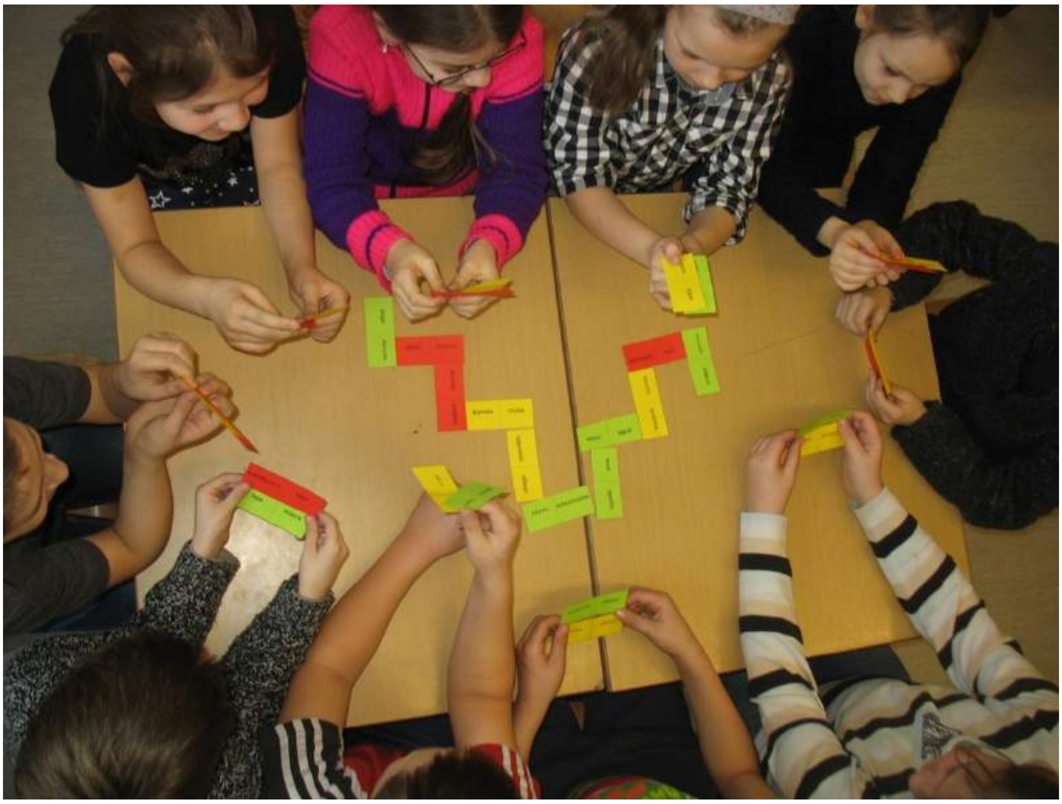


Image 5

While approving the methodological guidelines at the school and carrying out an analysis of the trial classes, I came to the following conclusions and suggestions for further actions:

- The more extensive the knowledge, the more creative the result, therefore it is necessary to use all of the possibilities for expanding the outlook of the children, starting with a fairy tale in the game room and ending with a tour at the planetarium.
- The driving forces of creatively minded personalities are interest, motivation and power of will, therefore the classes have to be organised in a manner that is interesting for the child, as an explorative, dynamic process that maintains the child's inner activity.

- A creative process is characterised by rich imagination, inspiration, courage and flexibility of the psyche, thus children have to be encouraged to suggest even the most audacious suggestions, so that they can transform into original ideas with time.
- Creative ideas should not only be new but also useful, therefore children have to be encouraged to analyse what they have done, choose the best options, as well as evaluate the most useful possibilities.
- Talented thinking is a skill that can be mastered, developed and applied, thus the mind has to be trained on a regular basis, so that it may grow into an inner necessity over time.