

## TRIZ and Pedagogy <sup>1</sup>

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### Functions of Pedagogy

Pedagogy (from the Greek *paidagogike*) is the science of educating people.

A basic consequence of human evolution was the growth in the amount of information that needed to be passed from one generation to the next. Pedagogy, as a way to transfer information, improved the course of evolution. It followed the criterion of ideality (as does any system created by human beings) by providing the maximum useful effect for minimum retribution in terms of money, work, time, loss of information, losses due to poor education, and so on.

In the early stages of human evolution, pedagogy, as we understand, did not exist. Children lived side-by-side with adults, contributed to housekeeping as they were able, and gradually acquired the necessary life skills without special training. As life became more complex, it became impossible to acquire the required knowledge and skills without special education. Furthermore, children hindered the activities of adults, which were becoming more complicated and, at times, dangerous.

Initially, pedagogy was more or less “individually” oriented. Only a small number of children (primarily the children of the wealthy) received education, which took place in the home. In the course of social evolution, however, it became clear that it is necessary to teach all children; and the demand for “mass pedagogic production” emerged. As in any area of human achievement, the transition to mass production resulted in deterioration in “product” quality. (The first muskets made on a mass scale were greatly inferior to hand-made ones.) And as in other areas, attempts were made to return to the past – to some method of individual education. This can benefit some individual children but, from a social viewpoint, has always been a “blind alley.” The correct way is to develop methods of producing high quality mass education.

Developing a “mass pedagogy” meant the creation of specialized subsystems – a type of “reservation” for children. The functions of these reservations are to separate children from the lives of the adults, and to purposely prepare them for, in due course, such a life. A child is isolated from social life and finds himself living within “protected walls,” like an astronaut in a space suit. To support life, an astronaut must have communication with other people as well as air, water, food, etc. – i. e., at least minimum compensation must be made for the absence of the common, earthy conditions of life. Similarly, children

<sup>1</sup> “Creative Pedagogy,” *Journal of TRIZ* 2.2.91, no. 4, pp. 9-17 (in Russian). Abbreviated, with translation and additions by Alla Zusman.

whose contact with society is interrupted should be compensated as well. Pedagogy is called upon to act as the “space suit’s” compensatory functions. This space suit should be made in such a way that a child will be well provided for. As the child matures, the size of the space suit must become larger and the child’s level of isolation diminish so that, when the space suit is removed, he/she can quickly become a full member of society. History has shown, however, that the pedagogical “space-suits” made by adults serve first and foremost the convenience of the adults.

Once mass pedagogy was developed, the simplest way to ensure its effectiveness was to force children to study and to punish them (even harshly) for insufficient studiousness. (By the way, the high level of education in Russia during the 1950 through 1970s accounted, to a large extent, for the strong system of punishment.) These methods are effective for acquiring knowledge and skills, but they restrain the child’s self-esteem, love of freedom, self-confidence, and so on. Moreover, these methods progress in countries that have totalitarian regimes, because the educational system is also totalitarian. But for these reasons, this method will not do for use in American schools. It contradicts the tendencies of the evolution of a democratic society. The democratic way to increase the effectiveness of education is to consider the child’s desires and needs.

### **Do Humans Need a Lot?**

Freud wrote that, a human being, in the beginning of his/her life, strives for pleasure. Later, he/she learns to correlate pleasure with possible retribution, i. e., begins to follow the “reality principle.” Thus, the human motivating power is striving for positive emotions (PE) and avoiding negative emotions (NE). Let us refer to this as “personal ideality.”

$$\text{Personal Ideality} = \frac{\text{Total PE}}{\text{Total NE}} \quad (\text{tends to increase})$$

The way to achieve positive emotions is through the satisfaction of certain human needs.

Abraham Maslow<sup>2</sup> formed a hierarchical structure of human needs – from physiological needs (the lowest) to spiritual demands (the highest).

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<sup>2</sup> Abraham H. Maslow. *Motivation and Personality* (Addison-Wesley Publishing Company, 1987).



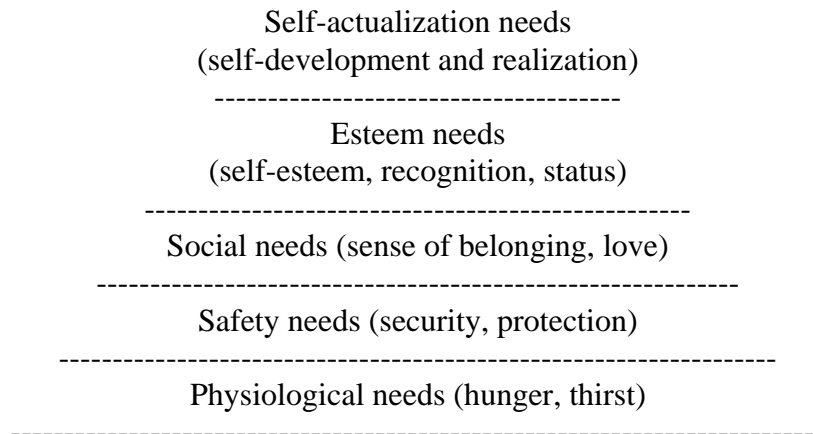


Fig. 1. Maslow's Hierarchy of Human Needs

Unsatisfied needs, the contradiction between the desire to satisfy them and the increase in retribution factors and limited resources, the contradiction between various needs, and between people in their struggles to satisfy these needs, were the motivating power of personal behavior and human progress.

Of course, Maslow mentions only basic needs that, to a certain degree, are inborn (i.e., genetically implanted). An infinite number of specific needs, more or less common and strong (ranging from a love of ice-cream to a love for symphonic music) are being formed, based on these needs, in the process of general human evolution and individual maturation.

One of the basic functions of pedagogy is the formation of a system of needs. Merely the formation of needs makes it possible to manage a child's education.

Existential (from the Latin *existentia*, "existence") needs are the needs that must be satisfied for basic existence. These are closely connected to the instinct of self-preservation, which requires a personal knowledge and understanding of one's surroundings, and of how to exist and be successful in these surroundings. These needs create an "investigative behavior" peculiar to every animated creature, and which, in people, becomes curiosity.

The human need for collective, imitative behavior (a child imitates others), and the possibility of enhanced prestige by means of education, can play a significant part in education.

However, our experience in educating children has shown that the most important need that allows the process of children's education to be managed is the need for creativity. There are various levels of creativity, as well as varying levels of creative content in

various kinds of work. The following basic conditions for creative work can be identified:

- The presence of uncertainty, or of a problem that can not be solved by known (by the would-be problem-solver, at least) methods
- The freedom to work without instruction as to when the work should be done, how, in what order, etc.
- The dependence of the results on the particular individual: his/her experience, intuition, will power, etc.
- The possibility of competing with someone (or with himself) to raise the level of achievement.

Viewed in this way, a farmer working his land is doing creative work. Weather conditions bring uncertainty. Crop yield depends on the farmer's work – on his hands and brain. It is up to him, to his intuition and experience, to take risks – to decide when he should sow, how to care for the crops, when to harvest, and so on. Likewise, the work of an engineer, manager, businessman, politician, etc. is, at least in part, creative work.

It is possible to presume that creativity plays the same part as do vitamins: a person needs only a small amount, but lacking them entirely leads to disease and developmental problems. And as with vitamins, a lack of creativity is especially dangerous for a young, growing person. Very often the importance of being able to satisfy higher-level needs is underestimated. People often believe that, if a person has a job and enough food and clothing he should be satisfied, without understanding the reasons for boredom, cruelty, vandalism . . . We can presume that unsatisfied needs demand a certain type of compensation, that an individual unconsciously seeks revenge on society for his/her deprivation.

But why are all children, and far from all adults creative? Why are they happy to work on creative problems and be able to solve them? Why does a child's natural curiosity turn into a powerful thirst for knowledge for one individual and not another?

Everything depends on involving a person in education and creativity through the psychological mechanism of engagement, based on alternating positive and negative stimuli. It is similar to the mechanism of involvement in sports, in collecting, in the need for glory and power, or for alcohol, drugs, etc.

This involvement begins when a child experiences pleasure in satisfying some natural need. This, in turn, leads to the desire to increase the pleasure. However, due to the human mechanism of habitual-ness, the level of pleasure falls when the previous level of satisfaction is maintained. It therefore becomes necessary to increase the "dose." A positive feedback loop develops, limited only by the physical potential of the individual.

It is possible to control the involvement in education through the human need for creativity. If there is a creative component in education, it allows victories to be

achieved, a person's self-esteem to be raised, and so on. This is why children enjoy competitive games.

More often than not, children become involved in creativity by chance, under the influence of a parent or enlightened teacher. Usually, however, only those children who are somehow pre-disposed to creative work become involved. The presence of the conditions necessary for this involvement is the first success. What happens if there is no success? Success that is too-easily obtained does not create strong feedback. Another important condition of involvement is the difficulties that usually follow a first success and that must be overcome. Excessive difficulty, however, can alienate a child and reduce his new-found desire to study and create. How can the level of creative effort be regulated? How can creative success be ensured?

These things are possible when the teacher is deliberately guided by the child's creative abilities, and with the Theory of Inventive Problem Solving (TRIZ). TRIZ is a new science that allows creativity to be approached systematically, providing the opportunity to teach any child to be creative and to develop creative ability in any area of human activity.

## **The Theory of Inventive Problem Solving and TRIZ Pedagogy**

TRIZ was developed in Russia<sup>3</sup> by Genrich Altshuller, a talented scientist and inventor, and his followers. Altshuller's work with TRIZ began in the 1940s and, to date, much experience in applying TRIZ application to various areas of human activity has been amassed.

TRIZ is based on the study and application of the patterns of evolution of various systems – technological machines, manufacturing processes, scientific theories, organizations, works of art, and so on. Based on these patterns, methods have been developed for searching for creative solutions. These methods include three basic components:

- The logical analysis of a given system and its problems. This enables users of TRIZ to understand the essence of a problem and to reveal the non-obvious contradictions that hinder problem solving.
- The application of a special knowledge-base that includes the most effective methods of problem solving, along with examples of how these methods are used.
- The means to overcome psychological inertia in the process of problem solving.

TRIZ enables users to perfect any system and to solve the overwhelming majority of creative problems. But what is probably the very essence of TRIZ: its use formulates a new way of thinking, one which is more logical, purposeful, and creative. To date TRIZ

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<sup>3</sup> Genrich Altshuller, *Creativity as an Exact Science*, trans. Anthony Williams. (Gordon and Breach Science Publishers, 1984).

has been applied to technology, science, medicine, forecasting, preventing and eliminating emergency situations and various undesirable phenomena (accidents, manufacturing defects, errors, crime, etc.), managing people and organizations, business, and so on.

Experience in using TRIZ has shown that it develops certain useful peculiarities in a TRIZ specialist's way of thinking, such as:

- The need for creativity; an orientation toward searching for and solving creative problems in various areas
- The ability to apply creative methods and models in various areas (for example, a person takes a TRIZ course for solving technological problems, but ends up applying TRIZ methods toward solving family or management problems, etc.)
- The development of a new type of intuition based on the patterns of evolution
- The ability to quickly and effectively assimilate knowledge in new areas. This is especially noticeable with professional TRIZ specialists, who successfully generate creative solutions for customers in various areas of human activity.

Altshuller began teaching TRIZ to engineers in the 1960s. Soon afterwards it became clear that it is impossible to teach creativity using traditional, non-creative means. The basic ideas of TRIZ pedagogy (for teaching adults and children) are as follows:

- The study of any subject as an evolving system
- The relationship between various subjects through the patterns of evolution of systems
- Teaching students to consciously apply creative problem-solving methods
- Teaching any subject via demonstration of the solving of creative problems
- Mastering the methods for overcoming psychological inertia.

For the education of children, TRIZ pedagogy has an additional set of objectives:

- The preservation and reinforcement of a child's natural creative inclinations
- The formation of a creative, vital orientation toward the achievement of Great Goals
- The formation of a creative way of thinking (by means of the special course "Developing a creative imagination")
- Mastering the TRIZ technique of quick learning.

TRIZ pedagogy was created for the purpose of teaching TRIZ. In the early 1980s, however, the authors attempted for the first time to apply TRIZ methods to teaching other scholastic subjects, first with physics and chemistry for 12-year-olds. This turned out to be very effective; students were very successful in learning the course material. The

experience has since been extended by many other specialists, who have applied TRIZ to teaching nearly all subjects for all age groups, from pre-school to the university level.

## **How Can We Teach Creatively?**

The principal premise of creative pedagogy is “learning should be fun.” The joy of education is, for the most part, related to its creative nature, to pleasure achieved through problem solving. This does not mean that all the education should be creative only. It is quite possible to use the elements of traditional pedagogy, “diluting” them from time to time with creative tasks.

The first steps in any education is the assimilation of new knowledge, comparing it with existing knowledge and ideas, revealing and resolving contradictions, determining the parts missing from the whole, verbalizing doubts with the purpose of formulating questions, and so on. This is typical of the creative process, and is what makes it so attractive. During the next stage of education, the assimilation of new ideas gives way to memorization. This is a non-creative process, however, even memorization can become more attractive by incorporating, from time to time, elements of creativity.

In the process of human evolution the most powerful tool for creative education – the game – was created. Games have all the components of creative work stated above. A game provides the complex assimilation of various kinds of knowledge, and develops practical skill, psychological skill, intellectual skill, etc. Games are oriented toward training and the satisfaction of all basic human needs. It is games that enable young children to assimilate the enormous quantity of information necessary to orient them in their surroundings.

Art can be considered “play” for adults. One of the basic functions of art is creative education by means of personal involvement in the process of co-authorship. For example, when a person listens to music, he is constantly and involuntarily playing a game: he is trying to guess what the next note will be; when listening to poems he is guessing the following rhyme, and so on. A person obtains his primary art education by perceiving (i.e., viewing, listening, etc.); then obtains a more profound and well-rounded art education by attempting to create his own (even poor) works of art.

Games have always been used as an auxiliary means of education. In the last few decades, methods of education based on games, including computer games, have become widely practiced.

All these are separate attempts to develop a system of complex education. They have one general defect, however: the basic element – teaching a methodology for creative searching – is missing. These attempts will never be successful without it.

TRIZ education should become a kernel around which all these separate methods can be unified. Consider the following example: the authors conducted a class where several dozens of new, original kaleidoscopes were invented using TRIZ. Kaleidoscopes were

invented that had mobile elements, that used electrical, chemical, and geometric effects, etc. Later, some calculation and design work was performed together with the children. They were given detailed explanations about optics, the rules of refraction in a lens, reflection in a mirror, dispersion of light in a prism, certain mathematical concepts, and so on. When conditions allowed, it would be possible to manufacture the kaleidoscopes they had invented, to introduce the elements of mechanics, chemistry, and so on, to work on a patent application for the kaleidoscopes. This would provide an opportunity to acquaint children with the elements of patent law, and so on. A TRIZ-coordinated system of tasks such as these could be created for various age groups.

## **A Child is an Inborn Creative Person**

In the early 1980s the authors studied the classic work of Jean Piaget on the peculiarities of a child's way of thinking. We were astonished by the analogies between a child's thinking and the TRIZ way of thinking (see Table 1). A comparison of adults', children's, and the TRIZ way of thinking allows us to draw a conclusion (not an original one; it has been widely discussed in the world of pedagogy)<sup>4</sup> that any healthy child can develop creative abilities in any area of human activity. When an adult studies a foreign language, he can support it with knowledge of his native language, he can draw an analogy, such as "der Tisch – the table," and memorize the word. But a child does not have such support; no one can explain to him/her what "table" means. He must make his own creative generalizations to recognize what can be called a table and what cannot. It is not yet been known how, i.e., by which psychological and physiological mechanisms, this tremendous creative work is performed, but only that they form the creative elements of a child's thinking. And it is not by a chance that these things are similar to the mechanisms of TRIZ thinking, which have resulted from extensive research and development.

Unfortunately, these natural mechanisms of a creative child's perception almost completely disappear later in life. Some people – but only some – preserve them to a greater or lesser degree. (It is not by mere chance that creative abilities often coincide with infantilism.) There are various reasons for this. On the one hand, the ability to speak makes it possible for a child to use a new cognitive method – simply ask. On the other hand, this more effective and economical, but less creative, way substitutes for the previous, creative way.

A 5- to 8-year-old child begins to master logic; his/her thinking gradually becomes more logical and less creative because the creative moment is paralogical. It cannot easily be transferred to someone whose thinking is based on logic. Language itself plays an important role in ousting creativity. According to the theory of "linguistic relativity" developed in the thirties in the United States by E. Sapir and B. Worf, the structure of language, to a large degree, determines the structure of thinking and the cognitive way

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<sup>4</sup> Rada Granovskaya. *Basics of Practical Psychology* (St. Petersburg: St. Petersburg University Publishing House. In Russian.) Also see numerous publications by the Russian educator and psychologist Boris Nikitin.

one experiences one's surroundings. All existing languages are based on classical logic. They were created not for the purpose of creativity, but for normal living.

The main reason, however, for the suppression of a child's creative abilities is most likely the absence of the conditions necessary for reinforcing and developing these abilities, as well as the lack of creative stimulation on the part of parents and teachers. Because it is responsible for public tranquillity, society is instinctively afraid of children who are too creative. Such children are unpredictable and often inclined to break tradition, discipline, etc. They attempt to do everything their own way, require additional attention, and so on.

The basic problem with the creative pedagogy of young children is mastering the "adult" way of thinking – logic – while preserving the elements of the child's creative approach. In contrast, for adults and older children the problem is to restore the lost creative thinking. TRIZ pedagogy has developed a special means for implementing both of these tasks.

When forming a person's creative needs and goals, one should bear in mind that it can make the person's life more complicated, can increase the level of stress, and so on. Therefore, along with a means for stimulating creativity, the "Vital Strategy of a Creative Person," was developed – a kind of educational course for developing activities for creative achievements, learning what dangers a creative person is likely to meet, and how they can be overcome.

As a creative personality, a child is not a match for modern "mass" pedagogy. French fashion designers consider the mop as the ideal female figure because a designer can drape it however he/she desires. The conditions of "mass pedagogy production" dictate standardization of the half-finished, as well as the final, "product." Individual characteristics and desires have been neglected (if they do not hamper the processing) or fought against. If the struggle does not yield results, the "half-finished product" is rejected in some way.

Almost everyone who has attended a regular school can recall some kind of student revolt against a teacher or against the educational system as a whole. This is the instinctive fight of the individual against the inevitable depersonalization of "mass pedagogic production." Working with children of various ages, the authors have become convinced that almost all of them have a negative attitude toward the pedagogical methods of their parents or teachers. They are sure that they know better how they should be brought up. A child's knowledge is limited, of course, but a child is capable of learning anything, including the process of participating in his own upbringing.

Every person, to some degree, is a "self-made man." Everyone to some extent plans and directs his own life, "builds" himself. The trouble is that in the majority of cases he does not know precisely what his goal is or how to achieve it; he does not know himself and his surroundings. In such a case, a creative teacher's purpose is to convey to the student the idea of self-perfection, and to help him achieve it. Creative pedagogy is an attempt to replace the battle between teacher and student with the child's struggle for self-perfection. The teacher is the child's assistant and ally in this struggle.

## What Should Future Creators be Taught?

This section of the article is not related to TRIZ pedagogy, but results from the application of TRIZ to the problems of improving education.

The ever-increasing load that students must bear is usually explained by the “information outburst” – by the enormous increase in the amount of information regarded as necessary. In reality this “outburst” is provoked by the accelerated development of methods of communication, which have outdistanced our system of selecting and processing information. As a result, an individual receives a tremendous amount of non-structured, often useless, information. Often he/she is simply unable to use this information due to a lack of the necessary knowledge and skills.

The majority of school curriculums are based on their creators’ personal experiences and preferences; sometimes they are based on prejudices, such as opinions regarding what knowledge a “man of culture” should possess.

It is necessary to develop a different approach to educational courses, based on the specificity of information and knowledge:

- Specific information: information that relates to specific problems. The average person faces such problems rarely, by chance only.
- Non-specific information: knowledge and skills that are widely used by the majority of people in various situations.

For instance, reading skills and a knowledge of basic arithmetic are non-specific skills, they are necessary for everyone. On the other hand, the proof of the Pythagorean theorem, knowledge of the frog’s third eyelid, and the name of the last ancient Roman emperor (Tarquili the Proud) are very specific. Of the 200 people surveyed by the authors, not one of them could prove the Pythagorean theorem and recall these facts or, at least, recall a situation where a need for these things had arisen. All this knowledge, however, is included in school curriculums<sup>5</sup>.

It is impossible, of course, to divide all knowledge and information on the basis of its specificity and the likelihood of its being needed in the future without extensive research. It is clear, however, that much of what comprises the curriculum in schools will turn out to be useless, and entirely new subjects will be included in future curriculums. We can attempt to name some of them:

- Information and skills necessary for survival, good health, and the ability to work. The elements of physical and psychological hygiene, sexual literacy, self-control, self-training (control of feelings, emotions, moods, reflexes, sleep, attention, ability to endure pain, and so on), self psychoanalytical skills, courage, self-restraint, self

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<sup>5</sup> In Russian schools, at least.

confidence, etc . Self protective skills, the ability to act appropriately in risky situations.

- Information and skills necessary for social life. Elements of psychology, communication skills, empathy. Elements of artistry, of the ability to talk and listen, to be convincing, to “read between the lines,” to distinguish truth from lies, to not submit automatically to suggestion, to overcome conformity. To be knowledgeable in the regularities of social functioning and evolution, basic laws, criminal and property qualifications, the basics of management, trade, business.
- Thinking skills. Logical, systematic approaches, formation of intuition and techniques for verbalizing rules, the ability to use abstract models, idealization, techniques for creative problem-solving, critical approaches, overcome psychological inertia, perform a probabilistic assessment, make decisions given unclear conditions.
- The ability to work with a knowledge base. Rapid reading and purposeful memorization, the ability to control one’s attention, to eliminate excessive information, to systemize it. Computer skills.
- Knowledge base. Profound knowledge of the environment – natural as well as technological. Knowledge of chemical, physical, and other effects that are encountered in the life of an average person. Understanding of basic scientific ideas, such as the theory of evolution, thermodynamics, mathematics, etc. Understanding of the basic ideas of the patterns of technological evolution and basic technologies. Understanding of the basic patterns of evolution of art, elementary skills in various kind of art.
- Manual labor skills; the ability to use simple tools. Ideas regarding various human specialties and activities (their merits and faults) sufficient for choosing a future profession.

Much of the knowledge and skills outlined above should be closely linked.

## What’s Next?

The authors and their colleagues have accumulated a great deal of experience in TRIZ education for adults and children, as well as in the teaching of other school subjects (physics, chemistry, geometry, biology, literature, etc.). Some of our particular experiences have been described in our books, which have been published in Russia (items 1 – 4).

1. Altshuller, Genrich, Boris Zlotin, Alla Zusman, and Vitalii Philatov. *Searching for New Ideas: From Insight to Methodology; The Theory and Practice of Inventive Problem Solving*. Kishinev: Kartya Moldovenyaska Publishing House, 1989.

The most complete source of Classical TRIZ information available. Summarizes the development of TRIZ up until 1988. Includes sections on the general patterns of

evolution, forming a creative personality, the theory of evolution of organizations, and elements of creative pedagogy.

2. STC Progress, *Solving Scientific Problems*. Kishinev: STC Progress in association with Kartya Moldovenyaska Publishing House, 1991.

This book is about applying TRIZ to solving scientific tasks and problems. It includes the materials on revealing and forecasting undesirable phenomena (manufacturing defects, accidents, and so on), and on developing scientific organizations.

3. Zlotin, Boris, and Alla Zusman. *A Month under the Stars of Fantasy: A school for developing creative imagination*. Kishinev: Kartya Moldovenyaska Publishing House, 1988.

Describes the experience of creative education in a summer camp. Contains recommendations for teachers or parents and can be used as a reading book for students.

4. Zlotin, Boris, and Alla Zusman. *The Inventor Came to Class*. Kishinev: Kartya Moldovenyaska Publishing House, 1990.

Describes methods for a creative approach to teaching various subjects at school, and can be used as a reading book for students.

5. Zlotin, Boris, Alla Zusman, and Svetlana Vishnepolska. *Petia and Dedalus; Teaching Youngsters to Create*. (Collection of articles published in a children's newspaper during the late 1980s).

Summarizes the experience of several years of teaching creativity to 1<sup>st</sup>- through 4<sup>th</sup>-grade students. The book consists of two parts: The first part, intended for children, is a collection of fairy tales in which the legendary inventor Dedalus helps young Petia to solve the most unexpected inventive problems. The second part, intended for parents and teachers, consists of teaching methods, recommendations and pre-planned lessons based on the stories in the first part.

6. Altshuller, Genrich. *And Suddenly the Inventor Appeared: TRIZ, the Theory of Inventive Problem Solving*. Translated by Lev Shulyak. Worcester, Massachusetts: Technical Innovation Center, 1996.

Summarizes the author's experience in teaching children via a central children's newspaper in the former Soviet Union during the 1970s. There are three editions in Russian, as well as various translations. Available in English.