

CREATION IN SCIENCE AND TECHNIQUE - A GENERAL APPROACH

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Abstract: As applied to science and technique a creative problem is defined as stemming from the resolution of a contradiction. The concept of state space for the problem is introduced and the abstract model for the problem as an element of the state space is proposed. Then the solving consists in extension of the space dimension. The contradiction is resolved by separation of the required contradictory properties into different coordinates. We present examples from different science and technique fields (mathematics, physics, biology, medicine and communications). It is noted that the proposed concept can serve as the basis for developing of practical methodology for creative problems solving.

Keywords: creative problem, contradiction, separation method

1. Introduction

1.1 In the paper we consider the creative process as a thought process only. Thereby we restrict ourselves by science and technique, and will not elaborate on creative processes related to art. Along the paper the term "creation" will thus be used in the sense of scientific and technique creation.

1.2 Two types of thinking – two types of sciences

"There are two kinds of people in the world, those who believe there are two kinds of people in the world and those who don't."

Robert Benchley

There are two well-established, types of thinking: rational (logical, analytical) and figurative (synthetic), relating to two cerebral hemispheres of the brain. In accordance with that, the knowledge can also be divided into the two (although with indistinct bounds) groups – logical and figurative (non-logical). The typical example for the first type is mathematics and the examples for the second type are art criticism and descriptive sciences. Naturally the real man's thought (as well as knowledge fields) possesses the both type features; however it tends to a greater or lesser extent to one of these poles. As for the sciences, it is because of that thought typization, they are also separated into the groups. So named descriptive sciences are being such because the subjects of their interests are often complicated and have so immense number of interior connections that only those possessing possibility to entire coverage (scope) could investigate them. That is the reason why the analytical type investigators could not approach to them for a long time.

2. Creative problem

"We know that the problem has no solution, but we wish to learn how to solve it."

*A.and B. Strugatsky,
 "Monday begins on Saturday"*

In order to discuss creativity problem, firstly we would like to determine what creation is.

As it was shown in [1] any psychological investigation includes irremovable act of introspection, so, strictly speaking, each researcher can produce his own personal conception. Correspondingly, the definition of creation given by psychologists is, as a rule, descriptive nature, due to their figurative thinking. Such typical, "averaged over set" determination [2,3,4 and references therein.] is approximately as follows:

definition 1: Creation (creative process) is a productive intellectual activity producing a non-trivial (non-obvious) result.

Accordingly to this approach, the creative process is represented as some "black box" with a new nontrivial result at the output. Without any attempts to belittle the importance of such definitions, we note, nevertheless, that they cannot satisfy investigators and practical workers with analytical way of thinking. They are more interested in definitions, characterizing the occurrence "inside the box". The break-through in this direction was performed in [5,6] as applied to technical inventions. There was shown that the invention process is resolving of a contradiction in a technical object. Following to [5,6] and expanding the field of application we give the

definition 2: Creation (creative process) is productive intellectual activity, allowing to reach a new result by resolution of a contradiction.

It follows from here the

definition 3: Creative problem is the problem of some contradiction resolution.

Claims 2 and 3 state indeed that contradiction and its resolution are necessary and sufficient tests for creativity. Thus, these claims allow to clearly distinguish between creative and non-creative thought independently of any subjective or objective novelty of the result. However, it yields necessity to explain what a contradiction is. We provide the following, suitable for our aim:

definition 4: Contradiction is the necessity for an object to possess two properties, each one excluding the other.

3. Model of creative problem and solution of creative task (creative process)

3.1 The space of states

The concept of state, as it seems, relates to primaries, irreducible concepts which are impossible to characterize by means of more elementary concepts. They are usually introduced descriptively with appeal to professional and worldly experience. The state of an object is usually determined with the number of generalized coordinates q_1, \dots, q_N , which can be numbers, functions and other objects. The set of the possible states is named states space. For example, the state of chess game is determined by the position of the pieces on the board, and the set of the possible positions is the state space. The concept of state space is widely used in numerous fields such as automatic control, pattern recognition and other.

3.2 The method of separation to solve of creative problem

Assume that a creative problem (as defined in the previous definition) applied to a given object A exists. Suppose that a N-dimensional states space $Q_N = \{q_n\}_{n=1}^N$ is associated to A. The object A possesses the feature B and the requirement is imposed to endow A with the property C, which is incompatible with B, holds for A. Consequently the following contradiction exists: there is the necessity for A to possess both B and C but it is impossible. As applied to the states space Q_N , it means that the generalized coordinate q_b holding the property B exists in Q_N . As for C, the contradiction exists because this property cannot have an associated coordinate in Q_N . Should any coordinate of the state hold C, the problem would be non-creative and could be solved with known methods, possibly requiring some corresponding qualification. The natural resolution of the contradiction lies in that the space Q_N should be expanded to Q_{N+1} by introducing an additional coordinate q_{N+1} , which would be able to hold C. Thus Q_{N+1} will be new states space for the new object, possessing the both properties B and C. We summarize the following principle for solving of creative problem:

Contradiction is resolved by introduction a new generalized coordinate into the state space and the separation of the contradictory properties into the different coordinates.

4. Examples

We provide below examples illustrating the applications of the presented principle. The examples belong to the several fields of science and technique.

4.1 Mathematics:

Complex numbers

The well-known elementary example, is the solution of the quadratic equation $x^2 - \alpha = 0$. The equation is solved by means of real numbers for the case $\alpha \geq 0$. The state space for the solutions is one-dimensional, it is real numbers axis ($-\infty < x < \infty$). The contradiction arises when $\alpha < 0$. On the one hand, the solution must exist, on the other hand it is not able to exist in the current state space. As it well known, the contradiction is resolved by introducing a second coordinate (the axis of imaginary numbers). Thus, one-dimensional space is expanded and turned in the regular two-dimensional complex plane.

4.2 Physics:

Helium superconductivity

Liquid helium flows through narrow capillaries (tubes) and slots without viscosity at ultra-low temperature. Thus the contradictory lies in both the presence and absence of viscosity. The contradiction was explained by construction of two component model; when the temperature is below $T = 2.17^\circ\text{K}$, the second component arises, so that helium has two components at the same time (two generalized coordinates) – normal (He-I) and super-fluid (He-II), existing independently one from the other) [7].

4.3 Communication techniques:

4.3.1 Difference phase shift keying (DPSK)

Development of communication systems has caused a permanent demand to increase capacity and performance under the bounding frequency and power recourses. One of intermediate stages on the development way of modern communication systems

was to use the phase of harmonic signal as the modulated parameters. It promised the essential improvement for performance without increasing of the transmission power and frequency band. However it required the reference signal with constant phase but it was not a success to extract of it from the information bearing modulation (DPSK). The new parameter was introduced into the signal - difference between phases of two consecutive signals and it was used as modulated parameter. Thus the dimension of parameters space was expanded from three-dimension (amplitude, frequency and phase) for four-dimension (amplitude, frequency phase and difference of phases) [8].

4.3.2 Reception of signals under near-zone fields interferences

The receiving antennas for radio signals very often have to be displayed close to transmitting antennas of several local radio stations (including piratical) and far from the source of information bearing signals. The contradiction consists in that it is necessary to receipt signals (useful) and do not receipt signals (harmful). The contradiction was resolved by the usage of the well-known effect – distinction between electrical and magnetic components of electromagnetic field. For the far-zone field these components are in phase and for the near-zone field the phase shift between the components is half period. The receiving antenna is at the far-zone field for the transmitting antenna of information bearing signals (transmitter) and it is placed at the near-zone field for the antennas of harmful signals transmitters. The common used receiving antennas respond to electrical component of electromagnetic field. Thus, the space of states has only generalized coordinate. We introduce the second coordinate – magnetic component. The component is received by the additional magnetic antenna. Owing to the difference between phases for near- and far-zone fields, the interfering and information signals can be separated and successful reception of the information signal is performed [9].

4.4 Biology:

4.4.1 Sexual division

During the evolution process of highly organized animals, the Nature had had to solve the following contradictory problem: to follow environment changes, organisms must be provided with the property of variability in order to adopt itself to the changes. On the other hand, it needs stability for preservation of useful changes. The contradiction was resolved by two-sexual nature of organisms. The nature assays variants of the changes on males by the random search method. The useful properties are fixed in females.

4.4.2 Dolphin sleeping

Like any other living creature, sleeping is necessary for Dolphins in order to rest and accumulate energy; on the other hand the Dolphin is not able to sleep because it has to be conscious in order to look out for possible predators (like sharks). Thus the following contradiction occurs: it has to sleep and it does not have to sleep. The contradiction is resolved as follows: dolphins have a unique ability called Unihemispheric slow-wave sleep which allows them to shut down only one hemisphere of its brain at a time giving it a possibility to rest. During this time the opposite eye is closed and the other hemisphere of the brain monitors the environment and controls breathing functions. In this case the contradiction is resolved by introducing an additional coordinate (the object performing the sleeping and consciousness functions).

4.5 Medicine:

4.5.1 Intracavity irradiation treatment of tumor disease

Malignant tumors of uterine body are one of the most severe diseases for woman. Intracavity irradiation is widely used for treatment of the disease. The medical procedure of the treatment consists in introducing of hollow bar into the uterine cavity through its cervical channel. Then a capsule with radioactive preparation is delivered pneumatically from the storage into the bar. After the procedure ending the capsule is returned to the storage. The main disadvantage of the method is its painfulness, caused by the bar size (1-1.5 cm diameter). The advantage is the possibility for intracavity radioactive irradiation. Thus the contradiction lies in the necessity for irradiation (for treatment) and impossibility of the irradiation (because painfulness). The contradiction was resolved by division in time: initially the size must be small (for painless introducing into the cavity), and afterwards the size must be large (for delivery treatment). It was realized with use of elastic (rubber, for example) balloon. Firstly the balloon is in a deflated state. It is introduced into the cavity through the cervical canal and then blown by radioactive gas, filling up the cavity. The extraction is performed in the inverse order [10].

4.5.2 Clinical research – placebo substances

The process of a new drug development includes several phases: Discovery and development, Preclinical research and Clinical Research – all those followed by a process of federal approval. After the preliminary development of the drug there is a need to test its efficiency such as its effect. This kind of testing is usually performed on a group of people who have the disease or condition that the medicine is developed for. One of the methods that are used to examine the effect of the drug is comparing several medical indicators between two groups: treatment (people who receive the drug) and control (people who do not receive the drug) groups. The participants of the experiment are assigned to one of these groups without being aware of the identity of the group they were assigned to - in order to neutralize any subjective psychological influence of the participants on the results of the experiment. This condition creates a contradiction – the participants that are selected for the control group have to receive medicine (in order to preserve the conditions of the experiment) but on the other hand they cannot receive the medicine (since the effect of the medicine is examined by comparing their medical indicators to the indicator of those in the treatment group). This contradiction is resolved by adding an additional coordinate – the degree of influence of the medicine. In this kind of experiments the people in the control group usually receive a Placebo medicine, which looks exactly like the drug given to the other group except that it excludes the active material of the drug itself and contains another substance that does not effects the medical condition of the participant.

5. The influence of inertia of thinking on creative process

Consider the following elementary training problem, which appears in many psychological books as the test for creative thinking .

Nine points are on a sheet, disposed at the angles, in the middle of sides and in the center of an imaginary square. It is required to trace the continuous line, composed of no more than four straight segments so that the line would pass over all the nine points. Emphasize that it must be done without lifting the pencil from the sheet and returning along the line. The solution is given in Figure 1. Once the solution is presented, it becomes apparent that the difficulties were caused by the attempts to remain in the bound of the square. It means that we tried to solve not the stated problem,

but another one, imposed by thinking inertia. The starting problem contained no contradiction. The contradictions aroused only in the models for the problem, formed by imagination (must be in the square and impossible to be in the square). This new problem turned out to be creative, and solved by expansion of the states space from the square to the whole plane. In essence we dealt with no contradiction, but rather with a kind of pseudo contradiction. As a rule, pseudo contradictions superimpose on real contradictions, hampering the solving.

Now we propose to continue the solving of the same problem, but instead of broken line it is required to draw only a straight line (one!). One of the authors carried out the experiment many times. The problem was insoluble before and was immediately solved after the familiarization with the content of the sections 2 and 3. The solution is presented in Figures 1 and 2.

If you solved also this problem, you are suggested to solve the same problem (only one straight line!) in the case of points disposed on a classroom board.

Fig. 1 - Test for creative thinking – nine points on a sheet using four straight segments

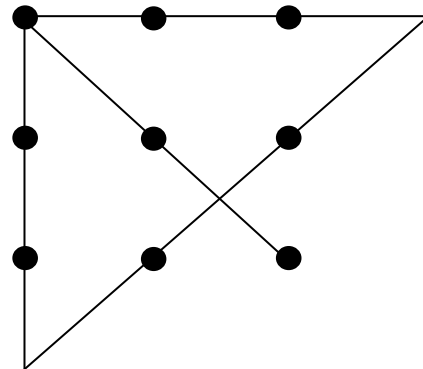
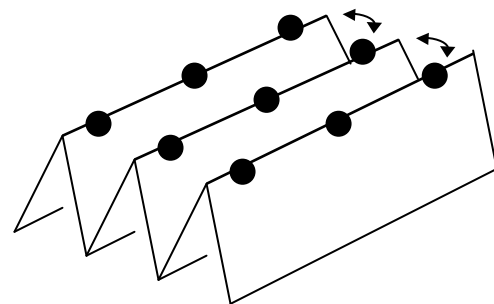


Fig. 2 – Advanced test for creative thinking – nine points on a sheet using a single line



* Later we found this problem is given in [11]

6. Discussion

6.1 First of all it is necessary to emphasize the difference between separation as a general principle for resolution of contradictions and the concrete applications of that principle that in the specific techniques for resolving specific contradictions. When creating inventions, the authors resolved contradictions without perception that they performed a specific realization of some general principle, although unknown for them. From this point of view, the known methods and the approaches to elaborate inventive

tasks (brainstorming, TRIZ and other) are, in essence, methods for searching of new coordinates in the corresponding state space.

6.2 Turn now to the issue about provability.

In mathematics and other connected scientific fields, the issue can be resolved perfectly when standard binary logic is used. Even ternary logic ("true-false-unknown") is not employed, so as "unknown" is considered as "false". In the natural sciences, based on experiments and observations, the issue is resolved by the requirement of experimental reproducibility, although it resembles very often the proposition to solve a scientific problem by vote [12]. Indeed only practice is the criterion for "true". In order to confirm or reject the proposed claim, the authors undertook the prolonged experiment, extended near fourteen years. A lot of mathematical, scientific and technical problems, which were undoubtedly creative, were examined. It may be said that the validity was being proved by the attempts of disproof. A resolved contradiction was found every time and it was resolved indeed with use of separation in the corresponding states space. Thus, one can assert that the separation is the general principle for resolution of contradictions in natural sciences, mathematics and technique.

7. Conclusion

"All generalizations are false, including this one"
Mark Twain

So:

7.1 Any creative problem is the problem for resolution of some contradiction.

7.2 Any contradiction is resolved by separation method, including the expansion of the problem's states space.

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