Inventive Thinking Development

V.Petrov

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1. Publication review

G. Altshuller from the beginning of TRIZ development has spare special attention to the creative imagination development [1]. In 1974, P. Amnuel published textbook [2]. In the years 1976-1978 B. Zlotin and S. Litvin developed the textbook [3-5]. A complete bibliography on the subject indicated in [6].

In 1978, the author, together with E. Zlotin formulated components of creative thinking [7].

In 2001-2012 N. Rubina formulated quality inventive thinking and developed a method for its diagnosis [8].

2. Components of inventive thinking

Based on 40 years of experience in teaching and the use of TRIZ, the author has identified six distinct parts comprising the inventive thinking. They are described in the following.

1. Systems Thinking.

2. Evolutionary Thinking.

3. Thinking Through Contradictions.

4. Resources Thinking.

5. Modeling Thinking.

6. Creative Imagination Development

2.1. Systems Thinking

System Approach is a necessary condition for the development of ***Systems Thinking***.

System Approach contains the following parts; *hierarchy*, *interaction* (of system components, system with super-system and the environment), *historical development*, *purpose* and *needs* identification, *building of a functional* model and the tree of system *operating principles* and *system level*.

The Systems Approach results from the use of the *System Operator* and the *System-oriented Approach*.

The System Operator is considers the *hierarchy*, the *historical development* and *anti-systems*. As can be seen in Fig. 1 there are 18 items (windows) to consider. The System Operator does not consider the environment and its interaction and interference on the system i.e. on the super-system, the system and the subsystem. We note that the reverse action (action of the system on the environment) is not part of the System Operator.

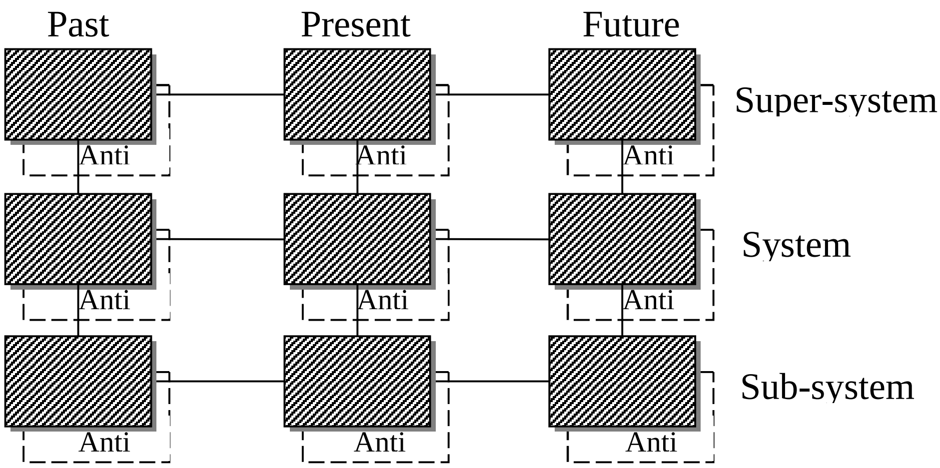

Figure 1. System Operator

The system-oriented approach consists of the following steps: determining purposes, needs, functions, operation principles and system (Fig. 2).

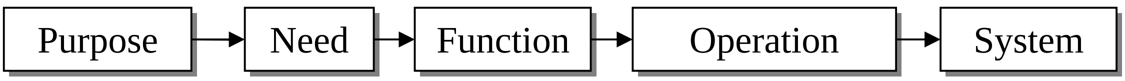

Figure 2. Steps of system-oriented approach

System-oriented Approach includes System-oriented Synthesis and System-oriented Analysis.

System-oriented Synthesis is applied for development a new balanced system – without disadvantages.

System-oriented Analysis is existing system in order to explore an existing system in order to reveal existing system's disadvantages.

The synthesis is carried out in the sequence indicated in Fig. 2, and the analysis in its reverse sequence (Fig. 3).

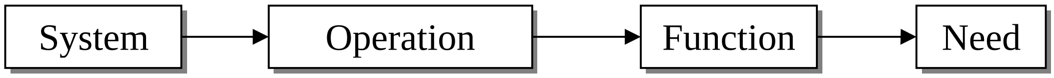

Figure 3. Steps of system-oriented analysis

2.2. Evolutionary Thinking

Evolutionary thinking has two components:

- Thinking according to the laws. Using the systems development laws for the development of a specific system.

- Identification of development patterns in any systems and phenomena, such as is done in IQ tests (sequence: triangle, square, pentagon ... now what?).

The systems development laws indicated in [9-17].

2.3. Thinking Through Contradictions

Thinking through contradictions – involves the identification and resolution of contradictions.

The best method is to use the logic of ARIZ [18].

We consider the whole chain of identifying contradictions: *administrative (AC)*, *technical (TC)*, *physical (PC)*, i.e. the chain to identify <u>cause-and-effect relationships</u> and *IFR* and the *Logic of ARIZ*, now we get the Inventive Problem Solving chain: **AC→TC→IFR→PC→Solution** and the logic of their relationship.

2.4. Resources Thinking

Resource thinking is identification and use of resources.

The author started his study of topic "Resources" in 1974 [19]. Later the author developed an identification and use methodology of resources [20-22].

Each resource must be specified:

- Cost: *Free, Cheap, Expensive*.

- Quantity: *Unlimited, Satisfactory, Insufficient*.

- Quality: *Harmful, Neutral, Useful*.

- Readiness: *Ready, Derivative*.

Resource structure is presented in the Table 1.

Table 1.

Resource Structure

Provision of Resources	Recourses Types														
		Structure				Field			Flow					System effect	
							Information								
	Function	Elements	Connection	Form / Shape	Substance	Energy	Data	Knowledge	Subst.	Energy	Inform.	Space	Time	Process	Result
System															
Subsystem															
Super-system															
Environment															

Algorithm for Use of Resources shown in Fig. 4.

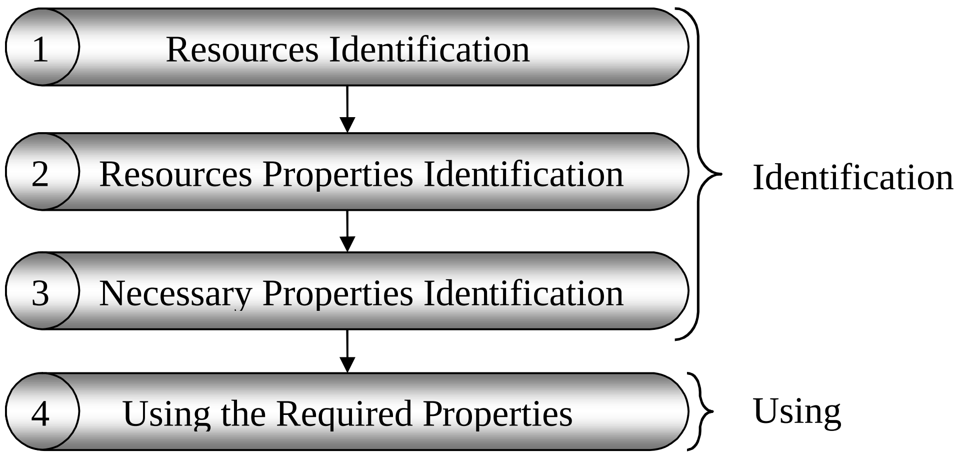

Figure 3. Algorithm for Use of Resources

Sequence of Application of Resources – Revealed Properties:

1. Application of system as a whole.

1.1. Application of basic properties, functions, actions as a whole.

1.2. Application of auxiliary properties, functions, actions as basic ones.

1.3. Application of unnecessary or harmful functions as useful.

1.4. Application of properties, functions and actions opposite to those revealed.

2. Application of subsystems (similarly to item 1)**.**

3. Application of substances and fields of subsystems.

3.1. Application of substance and field properties, which are basic for system and subsystem

3.2. Application of substance and field properties, auxiliary for the system, as basic properties.

3.3. Application of substances, unnecessary to the system and fields, as useful.

3.4. Application of substances, harmful to the system and fields, as useful.

4. Application of a subsystem's substance microstructure.

4.1. Application of the basic properties of a microstructure – molecules, atoms, elementary particles, etc.

4.2. Application of the system's auxiliary microstructure properties.

4.3. Application of unnecessary microstructure properties as necessary to the system.

4.4. Application of microstructure properties, harmful to the system, as useful.

2.5. Modeling Thinking

Modeling. Building and using models for solving inventive problems. TRIZ currently uses *Su-Field modeling*, *component and structural modeling*, *functional modeling* and *modeling with little people*. In addition it is desirable to create very simple models (use cardboard, clay etc.) sometimes a computer simulation is advisable.

2.6. Creative Imagination Development

Creative imagination development aims to manage the *psychological inertia*. For the development of creative imagination all known methods and principles [6] are used.

In addition the use of visual (in particular spatial imagination), auditory, olfactory, gustatory, tactile, kinesthetic, temperature sense of balance, proprioception – or "body awareness." Should be used as indicated in [7].

Psychological Inertia

In [5] describes the following types of psychological inertia:

1) Inertia of habitual function and functional directivity.

2) Inertia of habitual terms (special terms).

3) Inertia of habitual form, habitual appearance.

4) Inertia of habitual properties, states, parameters.

5) Inertia of habitual principal of operation, field of knowledge.

6) Inertia of habitual constancy of the object (pseudo-static nature).

7) Inertia of habitual composition, habitual components.

8) Inertia of habitual dimension.

9) Inertia of nonexistent prohibition.

10) Inertia of habitual action.

11) Inertia of uniqueness of solution.

12) Inertia of mono-object.

13) Inertia of habitual value (significance) of object.

14) Inertia of traditional application conditions.

15) Inertia of well-known pseudo-analogous solution.

16) Inertia of superfluous information.

The author has developed a classification of psychological inertia, partially described in [7]. The improved version has the following structure:

1. Inertia of goal setting.

1.1. Inertia of habitual purpose value.

1.2. Inertia of purpose realizability.

2. Inertia of identification and satisfaction of needs.

2.1. Inertia of habitual need value.

2.2. Inertia of need realizability.

3. Inertia of identification and execution of functions.

3.1. Inertia of habitual function value.

3.2. Inertia of habitual function value.

4. Inertia of habitual operation principle of the system towards change or detection (measurement).

4.1. Inertia of habitual operation principle value.

5. Inertia of system development, production, sale and disposal:

5.1. Inertia of habitual terms (special terms).

5.2. Inertia of habitual form, habitual appearance.

5.3. Inertia of habitual parameters (technical, ergonomic, economic, environmental, etc.).

5.4. Inertia of application.

6. Inertia of habitual traditions:

6.1. Inertia of habitual professional traditions.

6.2. Inertia of habitual company traditions.

6.3. Inertia of habitual national traditions.

6.4. Inertia of habitual regional traditions.

6.5. Inertia of habitual religious traditions, etc.

7. Inertia of prohibition.

There are special ways to eliminate psychological inertia.

3. Ways to develop inventive thinking

Inventive thinking is developed through continuous application of inventive thinking components.

3.1. Systems Thinking

System thinking is developed by using a *system approach*:

- Ability to see the *hierarchy of systems*;
- *Interconnection* and *interaction* of individual parts of the system with the super-system and the environment, and vice versa;
- Defining goals;
- Identifying and forecasting *needs*;
- Building a *functional model*;
- Identifying the *system's operation principle*;
- Construction of *structural* and *flow model*s;
- Determination of the system's workability and competitiveness.

3.2. Evolutionary Thinking

Evolutionary thinking is developed by identifying patterns in various phenomena, activities, systems and sequences; as well as by using the system development laws to predict the development of systems.

3.3. Thinking Through Contradictions

Thinking through contradiction is developed by identification and resolution of contradictions.

3.4. Modeling Thinking

Resource thinking is developed by identification and use of resources according to the algorithm (Fig 4) and sequence of application of resources (item 2.4).

3.5. Modeling Thinking

Modeling is developed by constructing mental, computer and physical models to solve specific problems.

3.6. Creative Imagination Development

Creative imagination is developed by using special principles and methods of creative imagination, by reading and appreciating science fiction.

3. Conclusions

The author has formulated the components of inventive thinking. The individual components of inventive thinking were first tested by the author on himself more than 40 years ago.

Subsequently, the author developed inventive thinking skills in his students by means of special exercises in the course of over 30 years. In the past 5-7 years the author employed the system presented in the paper to develop inventive thinking in students. The system proved its effectiveness. It changed the students' way of thinking and their approach to the solution of inventive problems.

The system of mastering the skills of inventive thinking is being constantly improved by the author. The paper presents the latest version of the system.

The paper also systematizes the causes of psychological inertia.

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