

## Using Innovative Methods Theory Instruction to Deepen Teaching Reform

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**Abstract.** In-depth analysis of recently published papers about college teaching, we can see the imitation and overlap of teaching reform, which is superficial. Teaching reform is in the process of innovation education for development. In fact, further teaching reform, needs more innovation theory and innovative methods, as well as needs forceful policy support. Based on the analysis of the basic theory of TRIZ inventive method, this paper presents a practical idea of using “Innovative methods” theory to guide the practice of teaching reform.

### 1. Introduction

Since 1999, large-scale expansion of higher education enrollment, higher education from elite education into the stage of universal education has been popular nationwide for mass application of heated Higher Education Teaching Reform, also has made a wealth of teaching research. However, in-depth analysis of these results, we can see the existence of the teaching reform imitative, repetitive too much, not enough depth of teaching reform. Education reform is the development of education in the process of innovation. Facts indicate that further deepen the reform of teaching, in addition to strong policy support, need more innovation theory and support of innovative approaches.

### 2. Independent innovation, the method first

Clearly stated the CPC's 17<sup>th</sup> congress, enhance independent innovation capability and building an innovative nation is the core of national development strategy, the key to enhancing the overall national strength. *Independent Innovation, the Method First*, Innovation is the fundamental source of independent innovation.

In order to implement the *National Long-and Mid-term Scientific and Technological Development Plan (2006~2020)*, National Four Ministries: the Ministry of Science and Technology, Development and Reform Commission, Ministry of Education and the China Association jointly issued *On Innovative Ways to Enhance the Work of Several Opinions* (April 23, 2008, hereinafter referred to as *Opinions*).

A long time, our attention to innovative methods of work is relatively insufficient, scientific thinking of cultivation is relatively backward, the activities in science and technology is still not

get rid of tracking imitate, less independent-innovation, sophisticated scientific instruments rely heavily on imports, and strengthening independent-innovation, building an innovative country's strategic requirements is extremely incompatible.

*Opinions* that: build for creative talents cultivation education system, and realization of quality education achieved by the exam-oriented education to quality education change; gradually change the situation of scientific research and technological development of imitation and dependent on imports of sophisticated scientific instruments.

*Opinions* requires us: To emancipate the mind, changing concepts, the innovative methods as a long-term strategic task, effective from the source to enhance capability of independent innovation, promote innovative country. Innovative methods to carry out the work, need strengthening mechanisms for innovation, management innovation and system innovation, and actively creating a favorable environment for innovation, to form the attention of innovation of the whole society, learning and innovation, and innovation of a good social atmosphere.

### 3. The five-level invention

The reason why the results of a technology achievements through the patent examination, patent certificate, will have its unique. However, some patents in the prior art system is based on a very small change, improvement of existing technical systems to a performance index; while others proposed a patent is non-existent prior to the technical system. Obviously, different levels of patents in innovation there is a difference. Determine whether a product or a technology innovative, how high their level of innovation is more important is to identify the product or technology innovation is the core of what. From a technical point of view, an innovation that is usually wholly or partially overcome a technical contradiction.

Soviet scientists in the research process Altshuller proposed a patented innovative evaluation criteria. According to the size of innovation, patents will be divided into five levels, as shown in Table I.

In the five levels of the invention, the Invention of the first grade only improves the existing systems, and does not resolve any contradictions in the technical system; the second and third grade invention solve the contradiction can be seen as innovation; fourth grade invention improve the technical system, but not solve the existing technical issue, but use some new technology to replace the existing technology to solve problems; the fifth is to use new principles and new phenomena of science invent to promote existing technology systems to a higher level.

Table I. The five-level invention

Invention level	Innovation Degree	knowledge Sources	Proportion (%)
1st- level	Individual parts of a simple system to improve Belong to the conventional design	Using the industry knowledge of the profession	32
2nd -level	Improve the system of local Belong to small inventions	Using the industry knowledge of different professional	45
3rd -Level	Essential to the improvement of the system Greatly enhance the performance of the system Belong to intermediate Invention	Use other industries in the professional knowledge	18
4th-Level	System is completely changed, a comprehensive upgrade of the existing systems Belong to Great inventions	Using the knowledge of other scientific fields	4
5th-level	Produce a new technical system, and promote the global science and technology Belong to major inventions	Knowledge is not used within the scope of known science, the science through the discovery of new phenomena or new material to create a new technical system	<1

Altshuller says that the invention of the first level is too simple, the fifth is too difficult. then he picks out the patents which belong to the second and the third level and fourth level from the mass

patents, to collate, research, analysis, generalize, extraction, and finally found the hidden rules behind these patents. **TRIZ** (Theory of Inventive Problem Solving) is the rules which is summed up and generalized on the basis of the analysis of the second to the fourth grade level. Therefore, the use of **TRIZ** can only help solve the first-level to the fourth level of the inventive problem of engineering technicians.

Altshuller consider: If not include technical contradiction, the problem is not the invention of the problem, or is not a **TRIZ** problem. This is a standard in determining whether the problem is invention problem. Note that the fourth level using previous theory which is not used before to achieve the main function of the existing systems, is a breakthrough solution. Therefore, strictly speaking, the problems which solved by the second, third, fourth and fifth grade invention are inventive problems.

#### 4. Theory of inventive problem solving (TRIZ)

##### 4.1 TRIZ architecture

**TRIZ** is proposed by former Soviet engineer and inventor--Altshuller in 1946, after studying a large number of countries around the world from the high level of invention patent, Proposing a system of relatively complete theory of inventive problem solving.

Altshuller in the analysis of the patent process, from different angles, using different analytical methods to analyze these patents, summarized a variety of rules. If divided by descending level of abstraction, these rules in the classic **TRIZ** can be represented as a pyramid structure, shown in Figure 1.

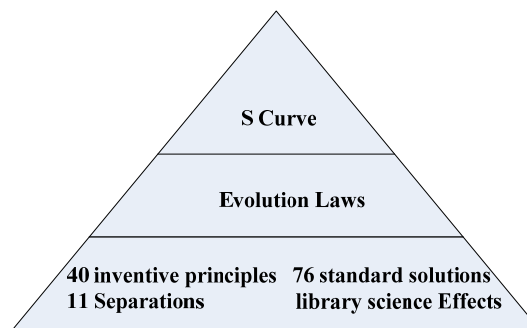


Figure 1. The Rules of Classical TRIZ

From a theoretical point of view, **TRIZ** Architecture can be expressed as a house-like structure, shown in Figure 2.

Can be seen from Figure 2:

- 1) **TRIZ** theory is based on natural science, system science and thinking science.
- 2) **TRIZ** philosophy category are Dialectics and Epistemology.
- 3) **TRIZ** originates from the mass analysis and summary of the patents.
- 4) The core of **TRIZ** theory is the evolution rules of technology system.
- 5) The basic concept of **TRIZ** contain the ideal degree, systems, functions, conflicts and resources Etc..
- 6) **TRIZ** innovative problem Analytical tools include root cause analysis, functional analysis, Substance-Fields Analysis, resource analysis and innovative thinking.
- 7) **TRIZ** innovative problem solving tools include the principles of the invention, separation methods, scientific effects database, the standard solution system and innovative thinking.
- 8) **TRIZ** for innovation in general problem solving algorithm is Algorithm for inventive problem solving (**ARIZ**).

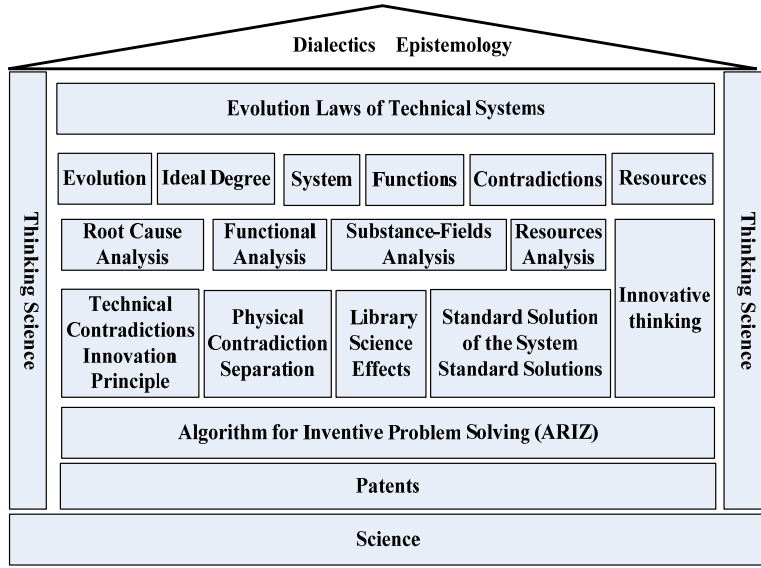


Figure 2. The Theoretical System of Classical TRIZ Structure

#### 4.2 Ideal degree, ideal system and ideal final result

**TRIZ** concept of the ideal degree is one of the foundations. based on it leads to Ideal System and Ideal Final Result. Ideal degree, ideal system and Ideal Final Result is important concept in **TRIZ**.

##### (1) Ideal Degree

The reason why each technology systems are designed, manufactured, is to provide one or more useful functions (UF). In these useful functions, only one of the most significant features is the purpose of technology systems, called the main function (PF), and also called the principal function or basic function. In order to achieve the main function, or enhance the performance of the main features, technical system also has several useful auxiliary functions called the auxiliary function (AF) or associated features. At the same time, each technical system will have one or more of what we do not wish to see the effect or phenomenon, known as the harmful function (HF).

Formula 1 shows the evolutionary trend of technical systems, namely, the definition of the ideal degree.

$$I = \frac{\sum_{i=1}^{\infty} U_i}{\sum_{j=1}^0 H_j} = \infty \quad (1)$$

Where, I is the ideal degree; U is a useful function; H is harmful features; i is the quantity of variables U; j is the quantity of variables H.

It can be seen from the formula 1, with the evolution of technical systems, systems in the quantity and quality of useful features are increasing; system function in the quantity and quality of harmful features are continuously decreasing. Therefore, the ideal of system is ever-increasing system, and ultimately tends to infinity.

By definition, the following three methods can be used to improve the ideal degree:

- 1) add useful features.
- 2) reduce harmful functions or cost.
- 3) The above 1) and 2) together.

##### (2) Ideal System

With the constant evolution of technology systems, the ideal degree will continue to enhance, That is the technical systems become more and more ideal. In **TRIZ**, the ideal system means that it does not exist as physical entities, nor consume any resources, but achieve all the necessary functions. The quality of the system, size, energy consumption infinitely approach zero; The function which system achieves tends to infinity. Therefore, it can be said that the ideal technical system is not material form (ie, zero volume and zero weight), nor consumes any resources (energy consumption is zero, the cost is zero), is able to achieve all the necessary functions.

Ideal system is only theoretical and idealized concept, and is in the ultimate state of the technical systems evolution. It is a ultimate ideal state which the real world could never approach. However, like the North Star, the ideal system find the ultimate goal of technical system evolution for designers and inventors. And it is the final standard of finding solutions and evaluating problems.

In the real world, the mission of designers and inventors is to continually improve the system by useful functions, to eliminate harmful functions and reduce costs, making technical systems gradually approaching to the ideal system.

### (3) Ideal Final Result

The ideal solution of a specific technical problem which is based on the concept of ideal system, is called the final ideal solution. Ideal Final Result is a concept extend from Ideal degrees and ideal system, is a psychological tool for the problem definition phase, is method which used to determine the direction of system development. It describes a solution beyond the mechanism of the original questions or constraints, and points out direction to solve practical technical problems when using **TRIZ** tools. This solution can be seen as the desired final state which is no connection with current problems.

The Ideal Final Result is an ideal solution for an already clearly defined the problem. Solving the problem by focusing on the desired visible ideal result, Ideal Final Result create the conditions for the subsequent use of other **TRIZ** tools to solve problems . In general, it can be used to define the following three basic forms of the Ideal Final Result:

- 1) system itself to achieve the required functions.
- 2) The system does not exist, but the required functions can be achieved.
- 3) make the system does not require this feature.

To define the Ideal Final Result as the beginning of solving the problem, has the following benefits:

- 1) help to generate breakthrough concept solutions.
- 2) Avoid choosing compromise solution.
- 3) help to establish the project boundary clearly through the discussion.

This powerful tool can not only be used in **TRIZ**, but also be used in other fields of science. It is an effective method for R & D staff to determine the ideal goal - how to obtain required function under not increasing the complexity of the system.

## 4.3 TRIZ and Contradictions

A large number of patents on research, Altshuller discovered that the real **Invention** (referring to the invention level of the second level, third level and fourth level of the patent) often need to resolve the conflicts hidden in the problem. Thus, Altshuller states: whether there is a conflict, the problem is to distinguish between conventional and invented one of the main features of the problem. It is a major feature of distinguishing between routine problems and invented one.

Therefore, we can simply believe that, if the problem does not contain contradictions, then the problem is not an inventive problem (or **TRIZ** problem). Different from the general design, only successfully eliminate the contradictions without affecting existing functions, it can be considered to be inventive to solve the problem. In other words, this conflict should be resolved as follows: In improving a part of technical systems, or optimizing a parameter of the system, while the other part of the function or other parameters will not be affected.

Contradiction is the cornerstone of **TRIZ**. Conflicts can help us to understand the root causes hidden behind the problem more quickly and better, and find solutions to problems. The starting point of **TRIZ** is fundamentally resolving a contradiction. **TRIZ** suggests that we should not avoid conflict. On the contrary, to find contradictions and intensifying conflicts, then resolve the conflicts.

## 5. Using Innovative Methods to instruct teaching reform

There is great repeatability and imitation of existing results of a large number of teaching reform. In fact, it can not be counted as innovation, at best, only as learning and improvement, similar to the first level of invention. In the long-term learning and improvement, we should deepen the reform of the teaching, achieve the real innovation in higher education reform by researching the invention of the second class and third class. This time, we need to learn innovative method and use it to guide our reform.

### 5.1 Solving steps of the general extension of TRIZ

**TRIZ**-based innovation process can be simply expressed as shown in Fig. 3.

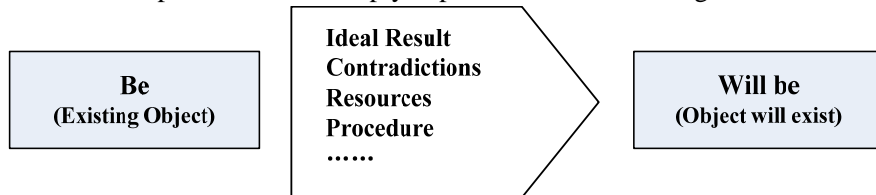


Figure 3. Re-Invention Based on TRIZ

**TRIZ** general problem-solving steps shown in Fig.4.

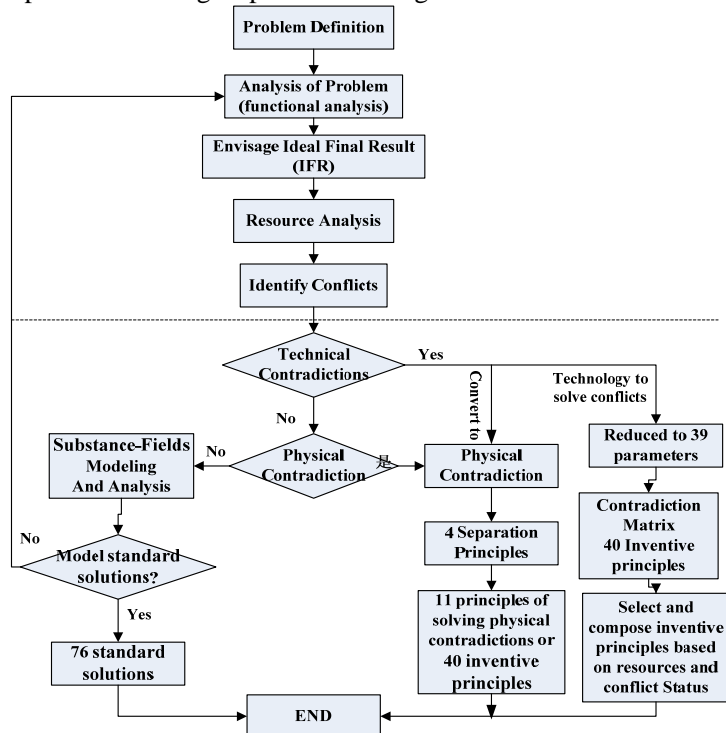


Figure 4. TRIZ Problem-Solving Steps

View on the current study, **TRIZ** method is based on the birth and development of machinery manufacturing industry, but also recognized and widely used in the manufacturing sector, has a great future. Be simple if the distinction drawn in Figure 4 on a dotted line, below the dotted line , **TRIZ** innovation method have a strong industry characteristics, that is, although most of the innovative approaches are already mature, mainly used for the Manufacturing industry. In the non-manufacturing sector, such as management, education and other areas, it is difficult to use specifically.

However, studies show that the portion above the dotted line in Figure 4, together with sub-sectors, sub-fields dotted by the following parts of **TRIZ** development thinking, namely, the methods and measures to resolve conflicts, the **TRIZ** innovative methods express important meaning and universal values . shown in Figure 5.

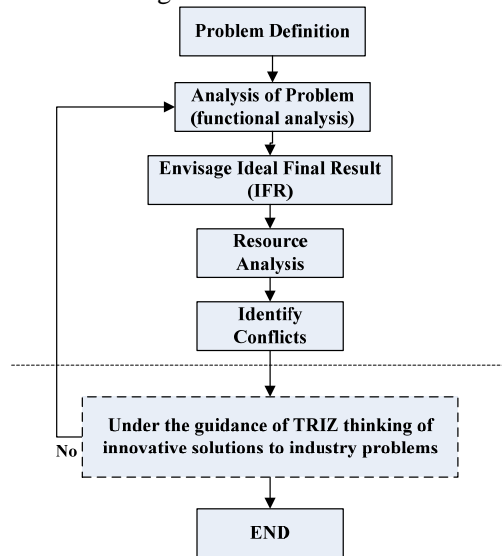


Figure 5. the Extension of TRIZ Problem-Solving Steps of Innovative Approaches

Teaching reform is the innovation in teaching in higher education. Independent innovation, the method first. To deepen the reform of teaching and enhance its effectiveness, we should study and promote the use of **TRIZ** innovative approaches by the scientific attitude and method to carry out teaching and research activities.

## 5.2 Envisage ideal final result

In the guidance of *Higher Education Act* and *National Long-and Mid-term Scientific and Technological Development Plan* and other relevant policies and regulations, best meet long-term demand of the social development for innovative human resources, best meet the learning needs and the talent needs of students, then teacher will enjoy teaching, students will enjoy learning.

This is the ideal education solution as we envisaged, and this educational environment that is our ideal education system, which is our long-term educational goal of teaching reform, our activities of teaching reform around this goal should be to expand.

## 5.3 Discovery and intensifying conflicts, and ultimately resolve conflicts

**TRIZ** method suggests that we should not avoid conflict. On the contrary, to identify conflicts and intensify contradictions. The problem of how to extract the contradictions hidden in the problems, is a complex and difficult but unavoidable issue. In practice, only through constant practice and conclusion that this ability can be improved.

**TRIZ** way of thinking is different from our traditional thinking and work methods, but help think and solve problems from the long-term needs.

For example, Universities exist widespread *Addiction* problem, and many schools is *Stop-Gap Measures*, usually a ban is over, provides that *Freshmen Not Allowed to Take the Computer* - attributed the cause of the problem to the network itself, such a solution in today's Internet age is in fact very naive. The result: Freshman to be under control, Questions focus on the outbreak when the semester of sophomore; school inside is under control, Off-campus Internet cafes is more *Prosperous*.

Giving an example, after the popularization of higher education, the style problems of teaching-oriented and applied-oriented collage generally stand out. During that time, many collage actively promoted the *Quasi-Military*, *Militarization* management of collage Freshman, and even the formation of a paper reform achievements. The result is: Short-Lived, this backward way of education is now ashamed to mention it.

The most typical is the spread of QQ. Ten years ago, when QQ is first popular among students, the *Insight* are often explosive jump on mentioning QQ thundering: *QQ Harms A Generation of Young People*. Today's QQ has been widely used and appreciated by society.

Why do we always stand in front of the trend, with it behind the times? These above examples, if re-analysis using **TRIZ** way of thinking, management and teaching methods are certainly not the case.

## 6. Afterword

In the history of human civilization, **TRIZ** first shows a way to resolve conflicts and to find effective methods of systems thinking, **TRIZ** spiritual perspective can continue to effectively organize other aspects of life, which helps people to overcome the blows of fate and helps people predict and avoid problems, but also helps people find a way when feel hopeless. However, these are strongly dependent on the individual's personality and experience of application of **TRIZ**.<sup>[6]</sup>

Teaching reform is innovative activity in higher education. Independent Innovation, the Method First. To improve the effectiveness of teaching, to deepen teaching reform, we must pay attention to the study and promotion of innovative approaches, with the scientific attitude and method to complete the historical and social responsibilities entrusted to us.

## 7. Acknowledgment

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