TRIZ-based Problem Definition Process for Creative Problem Solving

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Abstract

This paper introduces TRIZ-based problem definition process for developing students' creative problem solving ability in engineering education. TRIZ is the theory of inventive problem solving and was developed by a Soviet engineer and researcher Genrich Altshuller and its effectiveness was already proved by lots of real problem solving in various areas. Main obstructive elements of creativity are psychological inertia, lack of knowledge, wrong problem and avoiding conflict or contradiction. TRIZ provides tools and methods to overcome these obstructive elements. Therefore TRIZ might be very effective tool for developing and improving students' inventive thinking ability in education.

Incorrect problem definition will lead to wrong solutions and your effort for solving the problem will be a complete waste of time. In that sense, the ability for precise problem definition is no less important than problem solving. TRIZ-based problem definition process, we introduce in this paper, consists of the perceived problem definition, the real problem definition, and the problem verification stage. And each stage uses proper TRIZ concepts and methods to overcome psychological inertia and approach creatively. Especially we use visualization of the operating zone, technical and physical contradictions, IFR concept in the real problem definition stage.

Keywords: Creativity, Problem Definition, Perceived Problem, Real Problem, TRIZ, Inventive Problem, Contradiction, IFR, etc.

I. Introduction

Until now, engineers' main role is to solve given problems and engineering education also emphasize problem solving ability. Therefore they usually try to use easily perceived solution instead of trying to analyze the given problem and defining real problem, and go through lots of trial and error. But, these days the importance of speed is emphasized in the knowledge-based society and the repetition of trial and error cannot be beautified as endurance or effort any more. Especially companies must be very cautious about it. So, engineers require the ability to define real problem accurately before trying to solve problem. I think it is very important to develop this ability through engineering education.

Thus in this study we propose a problem definition process by using TRIZ[2,3,4,6,7] to define real problem effectively with minimal trial and error. This process consists of three stages such as the perceived problem definition, the real problem definition, and the problem verification stage. In this paper, we will describe the first 2 stages.

II. Obstacles to Creativity

There is strong connection and the distance at the same time between professional knowledge and creativity [8]. When you are lack of expertise, it is hard to produce creative ideas. On the other hand, extensive expertise doesn't promise any inventive ideas. Thus, the cramming education to transfer only major knowledge or creativity developing education unrelated with students' major is not that effective.

Then how to educate students to think creatively based on their major knowledge? The answer is to introduce creative thinking tools to fill up the gap between major knowledge and creativity. That is, we can connect major knowledge with creativity by using creative thinking tools such as brainstorming, mind map, TRIZ, and so on. In this sense, many scholars insist that we can develop our creativity by effort and learning. Especially, we can improve students' creativity systematically if we use effective educational technology.

There are many obstacles to creativity, but we listed four main obstacles in table 1 [5]. TRIZ provides many methods and concepts to resolve these four obstacles and we omit detailed explanation about it in this paper. This paper proposes TRIZ-based problem definition process in order to avoid wrong problems.

Table 1: Obstacles to Creativity

Psychological Inertia	**Lack of Knowledge**
o Custom and conventional way of thinking o Subjective reviewing	o Inter disciplinary knowledge o No tools or methods for accessing exact knowledge or solution
Wrong Problem & Definition	**Avoiding Conflict or Contradiction**
o Insufficient understanding of problem o Wrong problem definitions o Wrong directions	o Easy to compromise o Conceive impossible to overcome

III. TRIZ-based Problem Definition Process

3-1. What is TRIZ?

TRIZ is a Russian acronym for "Theory of Inventive Problem Solving". It was developed by a Soviet engineer and researcher Genrich Altshuller and his colleagues starting in 1946. It has been evolving ever since. TRIZ is not a psychological problem solving methodology of trial & error but a methodology, tool set, and model-based technology for generating innovative ideas and solutions for problem solving [2,4,11]. It is based on the analysis of creative solutions, i.e., patents.

3-2. What is Problem Definition?

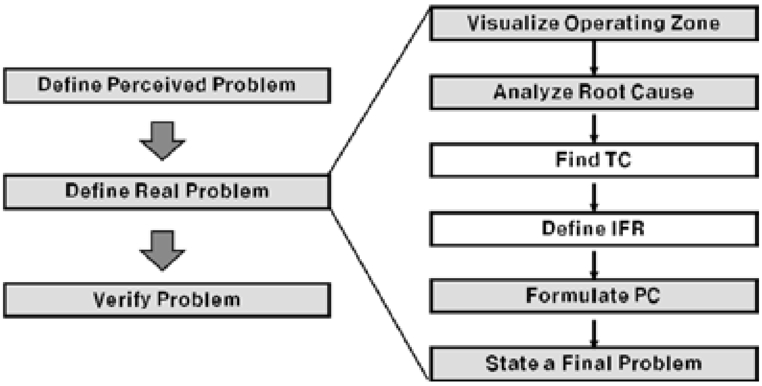
Problem definition means formulation of the real problem statement instead of the perceived problem for resolving the root cause of the problem. If you define wrong problem statement, although you produce good solutions for it, they are all useless and your effort will be a complete waste of time. But if you define right problem statement through analyzing the root cause of the problem, then the problem solving will be unexpectedly easy.

In this study, we have defined problem definition process using TRIZ concepts such as contradictions, IFR, system thinking, and S-curve. Meanwhile, this process is for only inventive problems. Inventive problems correspond to the level 3 or 4 out of 5 levels of invention which was classified by Altshuller and they are innovative and contain one or more contradictions [10]. A contradiction is a situation where an attempt to improve one feature of the system leads to the degradation of another feature [9].

3-3. Problem Definition Process

We have to define the 'real problem' in the problem definition process. If you don't consider alternatives enough and try to solve the problem with an easily occurred idea, you can fail to grip the very core of the problem and fail to solve it. Defining the real problem to solve the root cause of the problem is the key of this problem definition stage. Only one who knows what the problem is correctly can find correct solutions. We can summarize TRIZ-based problem definition process as Fig. 1 and gray boxes are necessary parts of it.

Figure 1: TRIZ-based Problem Definition Process



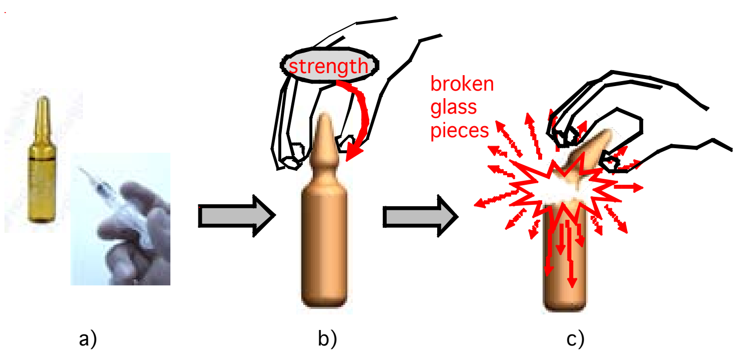
Although you perceive a problem, you can define it in various statements. Because the quality of the solution depends on the definition of the problem, defining the real problem is very important. Incorrect problem definition will lead to a waste of time and resource due to trial and error. Therefore, it is very important to educate students to build up a habit to spend more time for problem definition before trying to solve problems. In this paper, we only described the real problem definition step.

(1) Visualize Operating Zone
As we described before, inventive problems contain one or more contradictions and invention can be possible by removing the contradiction. So instead of analyzing all causes, you should focus on the root cause which leads to the contradiction within the problem. In order to do that, you need to identify the operating zone, the area where the contradiction occurs. In order to define the operating zone, you'd better depict the problem situation through the following three steps [3].

1. Use a photo or sketch the situation, which is helpful to understand the whole situation briefly.
2. Depict the operating zone where the core of a problem occurs.
3. Especially, describe the operating zone as magnified as possible. You don't need to finish it at a time and can describe it in detail with several tries.

For example, if you use the glass ampoule injection, lots of broken glass pieces in the glass ampoule can cause serious problem on the human body. Then, you can depict the situation as Fig. 2.

Figure 2: An Example of Visualization of an Operating Zone



(2) Analyze the Root Cause

In this step, you need to reinterpret the problem while watching the depicted operating zone in detail and analyze the root of the contradiction. In general, this step is useful to find a contradiction rather than producing solutions immediately. In the case of the previous example, via reinterpretation of the problem we can find a contradiction that glass ampoule is good for preventing chemical degeneration, but plastic ampoule is good for preventing the broken glass pieces.

(3) Find Technical Contradiction (Optional)

The technical contradiction (TC) is the classical engineering trade-off [1]. The desired state cannot be reached because something else in the system prevents it. Namely, one feature A gets better, another feature B gets worse. If the physical contradictions have been already revealed in the analyzing step of the root cause of the problem, you can skip this step.

In order to find TC, you need to describe about strength(feature A gets better) and weakness(feature B gets worse) in a condition and other strength(feature B gets better) and weakness(feature A gets worse) in an opposite condition in the following format.

TC1: If [a system is in a condition], there is [strength 1], but there is [weakness 1] too.
TC2: If [a system is in an opposite condition], there is [strength 2], but there is [weakness 2] too.

For example, high acceleration in a vehicle leads to increase fuel consumption. Then TC contained in this problem is as follows.

TC1: If [a vehicle has high acceleration], there is [strength that acceleration capacity is increased], but there is [weakness that fuel consumption is increased] too.
TC2: If [a vehicle has low acceleration], there is [strength that fuel consumption is decreased], but there is [weakness that acceleration capacity is decreased] too.

(4) Define IFR (Optional)

IFR(Ideal Final Result) is the ultimate idealistic solution of a problem when the desired result is achieved by itself. If you consider IFR, you will try to conceive optimal solution instead of taking a compromise immediately possible. It is very important because it can be connected with patents and innovation. You can define IFR in the following format as an optimal final result including both benefits in the contradictory conditions of the technical contradiction.

A Final Result including both [Strength 1] and [Strength 2]

In the case of the above technical contradiction, “Engine with increased acceleration capacity and decreased fuel consumption” can be an IFR. If a physical contradiction has been already revealed in the second step, you can define IFR in the next step.

(5) Formulate Physical Contradiction

Physical Contradiction (PC) is opposite/contradictory physical requirements to an object and it means contradiction between two different values of a feature. In other words, it is a situation where a feature has to have two different values at the same time. For example, the situation where wheels of airplanes must exist for takeoff and landing, but must not exist for reducing air resistance is a physical contradiction.

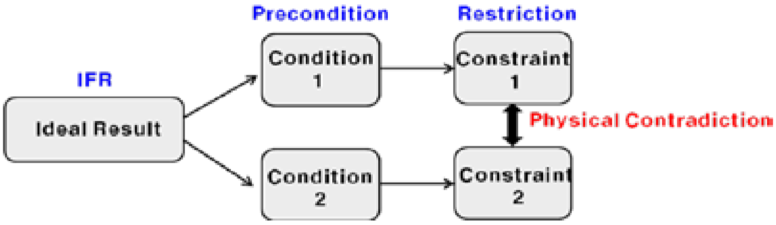
A physical contradiction can be revealed through the following three steps and if you get used to it, you can skip the second step.

1. Contradiction Analysis
   Find a physical contradiction in the operating zone where the problem occurs and fill out the following table,

Precondition 1	Precondition 2
Constraint 1	Constraint 2

2. Contradicted Situation Depiction (Optional)
   Describe two preconditions for achieving IFR and two constraints to satisfy each precondition as Fig. 3. If you had skipped the IFR definition step, a combination of two preconditions could be an IFR.

Figure 3: The Contradicted Situation Depiction



3. Formulation of a Physical Contradiction
   Finally, formulate the physical contradiction in the following format.

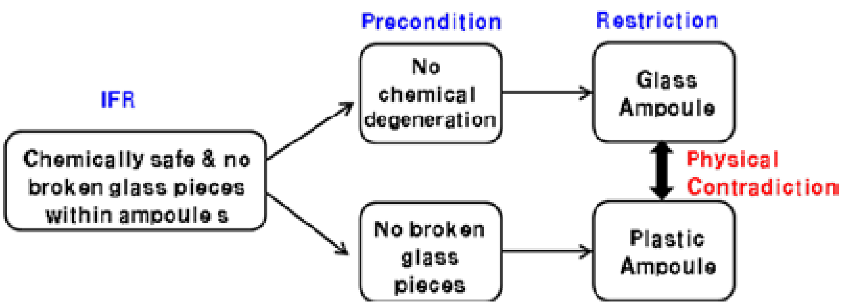
> For [Condition 1], [Constraint 1] must be satisfied,
> for [Condition 2], [Constraint 2] must be satisfied.

In the case of the glass ampoule problem, the physical contradiction can be produced as follows.

1.Contradiction Analysis

For preventing chemical degeneration	For preventing the broken glass pieces
Use glass ampoules	Use plastic ampoules

2. Contradicted Situation Depiction



3. Formulation of a Physical Contradiction

For [preventing chemical degeneration], we must use [glass ampoules] and for [preventing the broken glass pieces], we must use [plastic ampoules].

(6) State a Final Problem

Based on the above formulated physical contradiction, focus on which physical contradiction we have to remove in order to solve the root cause of the problem. And describe the final problem statement in the following format.

Resolve the contradiction that [Constraint 1] must be satisfied for [Condition 1] and [Constraint 2] must be satisfied for [Condition 2].

In the case of the glass ampoule problem, the final problem statement is "resolve the contradiction that we must use glass ampoules for preventing chemical degeneration and we must use plastic ampoules for preventing the broken glass pieces."

IV. Conclusion

Developing students' creativity is an important issue in education in the 21st century of knowledge-based society. So we need to recognize that creativity is a universal goal of education, where most students must arrive at. And I think we should focus on developing creativity by learning.

There are many principles related to creativity development, one out of it is that "creativity is augmented by creative thinking tools". In other words, the creative thinking tools play an important role in filling up the gap between major knowledge and creativity. So, we need to utilize creative thinking tools as such brainstorming, mind map, triz, and so on in education. Especially TRIZ, also known as the Theory of Inventive Problem Solving, provides very effective tools for exploding our psychological inertia that we usually try to solve perceived problems intuitively and empirically. Internally and externally many industries have produced remarkable performance with TRIZ in practical business.

Not only solving given problems but also recognizing and defining problems are important for engineers in the knowledge-based society. Therefore, in this study, we have introduced TRIZ-based problem definition process in order to develop students' creativity in education. Because creativity cannot be developed in a day through taking several related subjects, it is not easy to evaluate how effective the TRIZ-based problem definition process is in developing students' creativity. But, we intend to evaluate our process by applying creativity evaluation methods and will try to improve it.

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