

## Applying 6-Sigma and TRIZ Systematic Innovation Method to Explore the Influence of Positive Experience of University Students on Individual Creativity

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**Abstract.** Innovation can be viewed as a series of processes covering knowledge production, use, and dissemination. Creativity is the knowledge basis of innovation and innovation is the concrete practice of creativity. Creativity has an important influence on a successful country, and the development of students' creativity is a common trend of advanced countries. Therefore, how to improve students' creativity has become the most important current educational issue. This study combined the 6-sigma DMAIC improvement model with the "S-Fields" of TRIZ and enrolled students with "positive experience" as the subjects. The research results showed that the process capability index (Cpk) of students' personal creativity increased from 1.05 to 1.68. Therefore, positive experience does have an effect on personal creativity. Moreover, well-designed creativity courses can effectively improve personal creativity.

### Introduction

Innovation can be viewed as a series of processes covering knowledge production, use, and dissemination. Creativity is the source of innovation. Creativity is the knowledge basis of innovation and innovation is the concrete practice of creativity. A personal study of creativity mainly focuses on the characteristics of the creator, while personal characteristics are the nature of creativity [1]. Creativity has an important influence on a successful country, and a good education is the key to the success of creativity development [2]. The development of students' creativity is the common trend of advanced countries [3]. Therefore, the development of creativity and innovation abilities is the route to the development and strengthening of higher education's cultivation of talents that are much needed by society. Confronting facial diversity and the knowledge-driven economy, the abilities of creative thinking and problem solving will be the key basic capabilities in future higher education; thus, the cultivation of creativity is one of the necessary ways to improve students' competence.

The Theory of Innovative (Inventive) Problem Solving is referred to as TRIZ [4]. Currently, many scholars have been devoted to the research of TRIZ [5] [6][7]. The concept of using 6-Sigma to enhance industrial competitiveness and reduce product defect rates has been comprehensively discussed and applied in recent years. At present, there are many scholars devoting themselves to the research field of 6-Sigma [8]. This method applies to the quality control and analysis of the process,

improvement of the process' defect-free rate, and a reduction in the production of defective products. This study combined the 6-Sigma DMAIC model [9] with TRIZ and enrolled students with "positive experience" in positive psychological traits as the subjects to investigate and analyze university students' personal creativity. In addition to verifying that students' creativity can be improved through effective training to achieve the biggest advantage of reinventing education, this study can also provide the research results as reference for the promotion of creativity courses in Taiwan.

## Literature References

**Creativity.** Creativity is a process and is a novel and practical finished product produced by individuals in a specific environmental context. The process of irrational thinking is an important core of creativity [10]. Creativity focuses on conversion, flipping of thematic background, and delayed termination of creative thinking process [11]. A creativity test includes the intelligence test of convergent thinking and a creativity test for evaluating divergent thinking. Divergent thinking ability is a trait and is normally distributed in the population. In fact, people with a high score in this trait test are assumed to be creative people [12].

Creativity is a system, instead of an individual process. This system includes three different interactive systems: 1) personal gifts, personality traits, and motivation; 2) a domain composed of symbolic system, rules, skills, customs, and examples; and 3) a field composed of people in the same field (artists, scientists, critics, and journal authors; and the activities are restricted by the same rules and customs. Therefore, the creative process is between creative individuals with innovative ideas in a certain field and audiences accepting that such ideas are contradictory. Creativity encompasses ideas accepted by a social environment and passed down with the change of time. Therefore, creativity is a set of rules that have to be transferred from a domain to individuals, who are stimulated by a field in the domain to produce novel changes, which are then chosen by a field to enter the domain [13].

**Positive Experience.** Positive mood produces more creativity than neutral mood. Positive emotional condition (like happiness) produces creativity, while negative emotional condition (like sadness) is irrelevant to creativity, but a negative positive emotional condition (like anger) is related to lower cognitive elasticity [14]. Creativity is not only related to positive emotion, but also related to negative emotion [15]. In other words, positive emotion means safety, which promotes entertainment and extent thinking, while negative emotion means danger or uncertainty, which drives us to work hard to find creative solutions to solve problems. Creativity training promotes extensive thinking, creative solution, and work performance [16]. One should focus on the development of creativity and new cognitive skills rather than on creativity-related motivation, personal traits, or interpersonal skills - that is, creativity training can be made effective by a well-designed positive practice. Subjective well-being is a valuable experience, as well as a positive personality trait [17]. Subjective well-being is the experience of pleasant emotions and high life satisfaction, and such an experience originates from the subjective evaluation of enhancement of a positive emotion, reduction of a negative emotion, and improvement of life satisfaction. The positive experience specifically reflected by "subjective well-being" is the core concept of positive psychology [18][19].

**6-Sigma.** Motorola viewed 6-Sigma as quality indices in the mid-1980s. Because the technological advancements at the time were extremely complicated, the traditionally acknowledged and accepted quality levels were out of date. Therefore, the chance to produce defective products back then was high, and the defect rate was also relatively high. In 1989, Motorola announced a 5-year goal: the defect rate should be lower than 3.4 ppm, which could meet the standard of the 6-Sigma. This announcement not only challenged the quality concept that had existed in the U.S. for years, but also changed the perception of quality level. Instead of percentage (%), ppm or ppb is used as the measurement basis of quality [20].

**Process Capability Index.** The process capability index refers to the quantitative presentation of the relationship between real performance and specifications reflected in the process after the influence of non-random factors is excluded during the process, as well as the use of a simple

quantitative index to reflect the capability of the specification compliance of the process. The process capability index is the method most frequently used to measure process capability in quality control. Many important research results have been obtained in either theory or practice. This index is also frequently and widely applied by the manufacturing industry for quality monitoring to evaluate whether process capability meets a certain standard. Quality capability indices for evaluating a process:

**Capability of Accuracy,  $C_a$ .**  $C_a$  denotes the degree of offset of the process quality center. The lower  $C_a$  is, the better the process capability is.

**Capability of Precision,  $C_p$ .**  $C_p$  denotes the stability and consistency measurement index of process quality. The higher  $C_p$  is, the better the process capability is.

**Process Capability Index,  $C_{pk}$ .**  $C_{pk}$  is the combined measurement index of  $C_a$  and  $C_p$  that takes into account both the consistency and degree of offset of process quality. The higher  $C_{pk}$  is, the better the comprehensive process capability is. Levels of comprehensive process capability index  $C_{pk}$  and improvement strategies as illustrated in Table 1.

Table 1 Levels of comprehensive process capability index  $C_{pk}$  and improvement strategies

Level	$C_{pk}$	Improvement strategies
A	$1.67 \leq C_{pk}$	The process capability is outstanding and should be continuously maintained.
B	$1.33 \leq C_{pk} \leq 1.67$	The process capability is excellent and can be lightly improved to Level A.
C	$1.00 \leq C_{pk} \leq 1.33$	The process capability is common, and the process should be improved to Level B.
D	$0.67 \leq C_{pk} \leq 1.00$	The process capability is poor, and a review should be performed immediately or termination of production should be considered.
E	$0 \leq C_{pk} \leq 0.67$	The production should be immediately terminated, a comprehensive review should be performed, and emergency improvement measures should be adopted.

**TRIZ.** The Theory of TRIZ was proposed in 1946 by G. S. Altshuller, a former Soviet Union inventor, who is also regarded as the father of TRIZ. Altshuller started to lead the research institutes of former Soviet Union universities and enterprises to form TRIZ research groups starting in 1946 [4]. They analyzed nearly 2.5 million pieces of global high-level invention patents and put forward the basic theory on the problem of inventions based on dialectical materialism and systematic thoughts. The problem-solving tools of TRIZ include 39 engineering parameters, 40 invention principles, 76 standard solutions, Algorithm for Inventive Problem Solution (ARIZ), substance-field analysis, evolutionary trends, and scientific effects.

## Case Study

**Define.** In creativity assessment tools, an extensive thinking test is one of the most common tools to assess creativity, and TTCT is the most widely used questionnaire. Since TTCT includes article and picture tests, requiring a long time, Torrance believed that a simplified test would be more helpful, especially for the assessment of an adult's creativity. Therefore, in 1980 he developed Abbreviated Torrance Test for Adults (ATTA). This study adopted Torrance's ATTA as the test tool to test students' creativity.

**Measure.** This study took sophomore students in a science and technology university in central Taiwan as research subjects. These students had completed creativity lectures in their freshman year and studied a creativity course in their sophomore year. The population was 187 students in total. This study performed TTCT for 18 weeks in total. The pre- and post-tests were done in the 1<sup>st</sup> and the 17<sup>th</sup> weeks. In order to test university students' creativity ability indices, this study randomly enrolled 60 students and used Minitab software to calculate students' creativity test  $C_{pk} = 1.05 (< 1.33)$ , suggesting

that the score of students' creativity post-test improved compared to that of the pre-test. However, the progress was not significant. Students' creativity still could be improved (see Fig. 1).

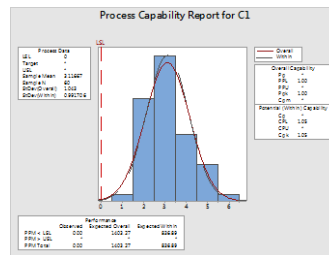


Figure 1. Finite Analysis on Students' Creativity Ability ( $C_{pk}$ ) before the Improvement

**Analyze.** This study used S-Fields of TRIZ to seek improvements of the contradictory issues. In Fig. 2, F is Individual Creativity, S1 is creativity course, S2 is TTCT. The post-test score of Torrance Tests of Creative Thinking for students' creativity improved compared to that of the pre-test. However, students' creativity still could be improved.

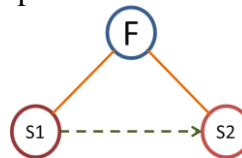


Figure 2. Finite "S-Field" of TRIZ

**Improve.** This study added S3 (positive experience) to "S-Fields" of TRIZ to improve the contradictory issues in the research results and performed the "S-Fields analysis" conversion of TRIZ (see Fig. 3).

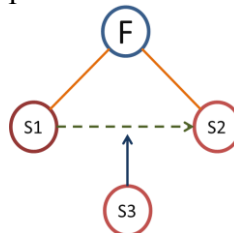


Figure 3. Finite "S-Field Analysis" of TRIZ after the Conversion

In order to improve university students' creativity ability, the course in this study used "scale on positive experience" to perform a test in Week 1 and enrolled 60 students with higher test scores. These 60 students were those with more positive experience among 187 students. The pre- and post-tests were done in the 1st and the 17th weeks. In order to test university students' creativity ability indices, this study used Minitab software to calculate students' creativity test  $C_{pk} = 1.68 (> 1.33)$ . The research result verified that there was a significant improvement in the creativity test score of students with more positive experience (see Fig. 4).

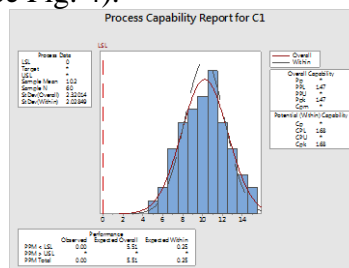


Figure 4. Finite Analysis on Students' Creativity Ability ( $C_{pk}$ )

## Conclusions

Confronting facial diversity and the knowledge-driven economy, the abilities of creative thinking and problem solving will be the key basic capabilities in future higher education; thus, the cultivation of creativity is one of the necessary ways to improve students' competence. This study combined the 6-sigma DMAIC improvement model with the "S-Fields" of TRIZ and enrolled students with "positive experience" as the subjects. The research results showed that the average improvement of score in the students' creativity pre-test and post-test for students with more positive experience was 10.2 points, while that of general students was 3.1 points. The average improvement of students' creativity pre-test and post-test was as high as 7.1 points. In terms of process capability index ( $C_{pk}$ ), the process capability index ( $C_{pk}$ ) of pre-test and post-test for students with more positive experience was 1.68, while that of general students was 1.05. Therefore, positive experience does have an effect on personal creativity. Moreover, well-designed creativity courses can effectively improve personal creativity.

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