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# LEARNING RESULT OF SYSTEMATIC INNOVATION COURSE UNDER DIFFERENT COGNITIVE STYLES FOR STUDENTS

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## Abstract

In a rapidly changing market environment, innovation and creative thinking should be the basic conditions and capabilities of enterprises with the advancement of technology. How to enhance the innovation capability of enterprises to make business in a highly competitive environment is the key to sustainable development. People's Innovative thinking tends to be in associated with their life experiences. Therefore, in solving problems, people will act according to both their own knowledge and awareness to seek answers. Such a problem- solving approach is often difficult to get breakthrough ideas and answers. All along, problem- solving approach in Taiwan's SMEs, mostly stay in traditional management thinking of pursuing standardization of quality, high efficiency and low cost. Companies must follow the trends of the digital age, and to find new competitive advantages and innovative business model, which is the business of sustainable business management. Kirton found that through different adaptability and appropriate combination of innovative personnel, the overall innovation capability can be effectively improved (Kirton, 2003). Bobic, Davis, and Cunnignham (1999) found in their study that to have adaptability and innovative tendencies personality in a team, the performance will be significantly better than to have only one single kind of tendencies in a team. In this study, one master and one bachelor class of Industrial Management Department, I-

Shou University were chosen as the object to explore whether innovative personality traits will be improved or enhanced under innovation programs. Data were analyzed using paired T tests, 2- Sample T tests and other statistical methods, with experts to discuss the effectiveness of the generated data. The results can be provided to enterprises so as to enhance employee creativity.

Keywords: Learning Result, Cognitive Style, KAI, Systematic Innovation

## Introduction

With the advancement of the technology, and in the market environment with rapid changes, innovation and creativity are the basic conditions and capabilities that enterprises should possess. Problem- solving research is also paying more and more attention to the impact of cognitive style on innovative behavior. KAI (Kirton's Adaption- Innovation Inventory) theory divides people into adjusters and innovators based on cognitive style. The adjusters tend to do better in the existing paradigms, and the innovators tend to break through the existing paradigms and solve problems in new ways.

In this study, the KAI scales were tested in the beginning to the students to understand their innovative personality traits. After the KAI test, we conduct a test of innovative problem solving in groups before students receiving any course training,. Then we arrange a series of systematic and innovative training courses, including mind map, six thinking hats, brainstorming and TRIZ theory, hoping to enhance creativity of students through these courses. After the end of the courses, we conduct a group-based innovative question test and another individual- based innovative question test and an innovative course questionnaire for each student. Finally, using the test data, questionnaire data, and KAI scale data, statistical analysis are performed to investigate the relationship and effect of innovation courses on creativity of students.

## Literature Review

### *Cognitive Styles*

The concept of cognitive styles was first proposed by Allport (1937). It refers to an individual's typical or habitual way of perceiving, remembering, thinking, and problem solving. Since then, there has been considerable study in this area. Cognitive styles have been investigated broadly by psychologists. Messick (1976) identified that there are as many as 19 cognitive styles. Smith (1984) also appointed at least 17 learning styles. There are many different ways to define cognitive style. Riding, Glass, and Douglas (1993) termed cognitive styles as "a fairly fixed characteristic of an individual" and "are static and are relatively in- built features of the individual".

### *KAI theory*

Kirton's adaptive- innovative theory (2003) was proposed to explain cognitive tendencies and problem-solving styles. In his classification, there are two kinds of cognitive styles. Adaptors want to do things better; innovators seek to do things differently. KAI is a theory that attempts to explain differences in creativity and, in this understanding, create more cohesion and collaboration among team members. Kirton also established a KAI inventory to measure the cognitive style of adaptors and innovators (Chan, 2000; Taylor, 1993).

*Creativity and innovation*

The ideas of creativity and innovation have been debated over the years. As Anderson et al. (2014) state: "Creativity and innovation at work are the process, outcomes, and products of attempts to develop and introduce new and improved ways of doing things." The creativity stage of this process refers to idea generation, and innovation refers to the subsequent stage of implementing ideas toward better procedures, practices, or products. Creativity and innovation can occur at the level of the individual, work team, organization, or at more than one of these levels combined but will invariably result in identifiable benefits at one or more of these levels of analysis." Thus, in an organizational context, creativity and innovation have an anticipated benefit to the organization and a tangible output (Patterson, 2002).

*TRIZ theory*

TRIZ is a Russian acronym for "Theory of Inventive Problem Solving" (Yeoh, Yeoh and Song, 2011). It is a systematic innovation theory developed by Genrich S. Altshuller after analyzing thousands of patents in the 40s. TRIZ has been successfully implemented by big companies, such as Samsung, General Electrics (GE), Intel, and many others to assist with product and technological innovation (Hamm, 2016).

TRIZ theory is based on "contradictions that can be methodically resolved through the application of innovative solutions" (Labouriau and Naveiro, 2015). It has three premises; an ideal design; contradictions that help to solve problems; innovative process which can be structured systematically.

Research Framework

There are two hypotheses in this research to explore the impact of systematic innovation teaching, KAI scores on the effectiveness of creativity learning. Creativity is measured by the difference between the pre- and post-teaching problem- solving test. The problem is to ask students in group to propose as many ways as how to throw an egg from the second floor and keep it intact. A group of innovation teaching experts were invited to score these two runs of proposed solutions from each group.

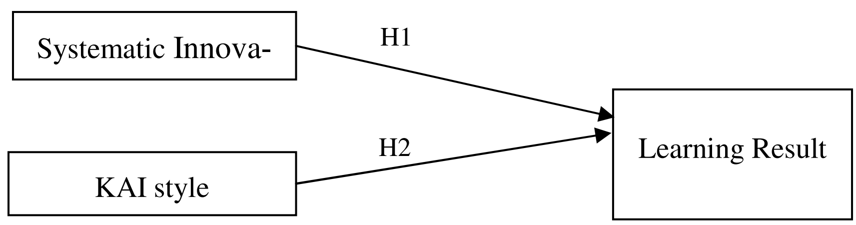


Figure 1. Research Framework

H 1. Systematic innovation tools are positively help for group creativity improvement.

H 2a. Grouped KAI average problem-solving scores will affect group creativity learning outcomes.

H 2b. Grouped KAI range of problem-solving scores will affect group creativity learning outcomes.

H 2c. Grouped KAI standard problem-solving deviation of scores will affect group creativity learning outcomes.

## Result Analysis

This study was conducted in two classes, one for the university department and one for the graduate program. Students are grouped at the beginning of the semester. Due to the number of students, the students of university were divided into 11 groups, and those of the master class were only divided into 4 groups.

### *Hypothesis 1*

For hypothesis 1 that Systematic innovation tools are positively help for group creativity improvement, the 'eggs fallen down from the second floor' problem was employed. Each group proposed solutions and were scored by experts according to the quality and quantity of the creative, and the problem- solving tests were performed twice, one in the beginning of the course and one after the whole course was completed. The statistical analysis for hypothesis is paired t test.

Table 1. Test Scores Before And After Course

| Group | Before | After | Class |
|---|---|---|---|
| 1 | 1.65 | 1.68 | college |
| 2 | 1.98 | 1.88 | college |
| 3 | 1.64 | 1.84 | college |
| 4 | 1.77 | 1.91 | college |
| 5 | 1.83 | 1.80 | college |
| 6 | 1.82 | 1.98 | college |
| 7 | 1.70 | 1.83 | college |
| 8 | 1.70 | 1.71 | college |
| 9 | 1.70 | 1.82 | college |
| 10 | 1.79 | 1.91 | college |
| 11 | 1.62 | 1.88 | college |
| 12 | 1.85 | 1.80 | graduate |
| 13 | 1.67 | 1.66 | graduate |
| 14 | 1.69 | 1.83 | graduate |
| 15 | 1.88 | 1.75 | graduate |

The statistical results (Table 2) show that the P- value of the problem-solving ability of each group of the university department before and after the systematic innovation course is 0.012 , which is significant under the significant level $\alpha$ = 0.05. The result shows that the learning of systemic innovation tools can effectively improve the effectiveness of group creativity for college students. On the other hand, the p value of pair t test of graduate school students is 0.839, which is insignificant under the significant level $\alpha$ = 0.05.

Table 2. Paired T for College Students

| | N | Mean | St Dev | SE Mean |
|---|---|---|---|---|
| Before | 11 | 1.7455 | 0.1061 | 0.0320 |
| After | 11 | 1.8945 | 0.1125 | 0.0339 |
| Difference | 11 | - 0.1491 | 0.1622 | 0.0489 |

95% CI for mean difference: (- 0.2581, - 0.0401)
T- Test of mean difference = 0 (vs not = 0): T- Value = - 3.05 P- Value = 0.012

Table 3. Paired T for Graduate Students

| | N | Mean | St Dev | SE Mean |
|---|---|---|---|---|
| Before | 4 | 1.7425 | 0.1078 | 0.0539 |
| After | 4 | 1.7600 | 0.0744 | 0.0372 |
| Difference | 4 | 0.0125 | 0.1132 | 0.0566 |

95% CI for mean difference: (- 0.1677, 0.1927)
T- Test of mean difference = 0 (vs not = 0): T- Value = 0.22 P- Value = 0.839

According to the score data of the college student, 9 groups out of 11 were improved after the innovation course, and 2 groups were lowered. Using paired T test, the P value is significant, which means that the courses is helpful to the group creativity. But the score data of the graduate students showing that one group has been improved and three groups are lowered. The P value is not significant. This means that the course is less helpful in improving the effectiveness of their group creativity through the innovative courses in this test. There are several possible reasons for this result:

1. The number of samples is insufficient, and the number of groups tested in this class is too small to achieve effective statistical analysis.

2. In the process of systematic innovation tools course, the college students are more willing to learn compared to students of graduate school.
3. It was also found that the participation and small practices of college students were better than those of the graduate students.

*Hypothesis 2*

Similarly, ΔI (average score after learning - average score before learning) is used to perform regression analysis on (2a) the average KAI score of each group (2b),range of the KAI score of each group and (2c) standard deviation the KAI score of each group to test if various KAI statistics will affect group creativity learning.

Table 3. The KAI score statistics vs ΔI

| Group | ΔI | Aver-age_KAI | Range_ KAI | SD_KAI | class |
|---|---|---|---|---|---|
| 1 | 0.5 | 89.33 | 31 | 10.42 | college |
| 2 | 0.1 | 90.83 | 16 | 6.08 | college |
| 3 | 0.2 | 92 | 14 | 5.73 | college |
| 4 | 0.14 | 86.2 | 14 | 5.17 | college |
| 5 | 0.03 | 93 | 10 | 4.55 | college |
| 6 | 0.16 | 86.86 | 30 | 10.14 | college |
| 7 | 0.13 | 88.33 | 13 | 7.23 | college |
| 8 | 0.01 | 91 | 10 | 4.55 | college |
| 9 | 0.25 | 90.17 | 33 | 12.46 | college |
| 10 | 0.12 | 87 | 12 | 8.49 | college |
| 11 | 0.26 | 97 | 25 | 13.89 | college |
| 12 | 0.05 | 90.33 | 7 | 4.04 | graduate |
| 13 | 0.01 | 88.67 | 5 | 2.52 | graduate |
| 14 | 0.14 | 83.5 | 12 | 5.2 | graduate |
| 15 | 0.13 | 98.33 | 39 | 19.5 | graduate |

The statistical results show that the test p values of ΔI on the average KAI score of each group for college and graduate students are 0.889 (Table 4) and 0.907 (Table 5) respectively. The test results are both not significant, so the results show that the team's cognitive style average KAI score has nothing to do with the effectiveness of the creativity learning.

Table 4. Regression of ΔI on Average_KAI for College students

| The regression equation is I = - 0.01 + 0.0020 Average_KAI | | | | |
|---|---|---|---|---|
| Predictor | Coef | SE Coef | T | P |
| Constant | - 0.009 | 1.272 | - 0.01 | 0.994 |
| Average-KAI | 0.0020 | 0.0141 | 0.14 | 0.889 |
| S= 0.141032 | R- Sq = 0.2% | R- Sq(adj)= 0.0% | | |

Table 5. Regression of ΔI on Average KAI for Graduate students

| The regression equation is I = - 0.003 + 0.00095 Average_KAI | | | | |
|---|---|---|---|---|
| Predictor | Coef | SE Coef | T | P |
| Constant | - 0.0032 | 0.6512 | - 0.00 | 0.997 |
| Average-KAI | 0.0010 | 0.0072 | 0.13 | 0.907 |
| S= 0.076723 | R- Sq = 0.9% | R- Sq(adj) = 0.0% | | |

The statistical results show that the test p values of ΔI on the KAI score range of each group for college and graduate students are 0.008 (Table 6) and 0.344 (Table 7) respectively. The test results are significant for college students but not significant for graduate students. It turns out that for the college students, the team's cognitive style KAI score range will affect the effectiveness of the creativity learning, but for the graduate students, it has nothing to do with the effectiveness of the creativity learning.

Table 6. Regression of ΔI on KAI_Range for College students

| The regression equation is I = - 0.0395 + 0.0112 KAI_Range | | | | |
|---|---|---|---|---|
| Predictor | Coef | SE Coef | T | P |
| Constant | - 0.0395 | 0.0683 | - 0.58 | 0.577 |
| KAI_Range | 0.0112 | 0.0033 | 3.41 | 0.008 |
| S= 0.0932437 | R- Sq = 56.4% | R- Sq(adj)= 51.5% | | |

Table 7. Regression of ΔI on KAI_Range for Graduate students

| The regression equation is I = 0.0413 + 0.00261 KAI_Range | | | | |
|---|---|---|---|---|
| Predictor | Coef | SE Coef | T | P |
| Constant | 0.0413 | 0.0444 | 0.93 | 0.450 |
| KAI_Range | 0.0026 | 0.0021 | 1.23 | 0.344 |
| S=0.0581802 | R- Sq = 43.0% | R- Sq(adj)= 14.5% | | |

The statistical results show that the test p values of ΔI on the KAI score standard deviation of each group for college and graduate students are 0.029 (Table 8) and 0.386 (Table 9) respectively. The test results are significant for college students but not significant for graduate students. It turns out that for the college students, the team's cognitive style KAI score standard deviation will affect the effectiveness of the creativity learning, but for the graduate students, it has nothing to do with the effectiveness of the creativity learning.

Table 8. Regression of ΔI on KAI_SD for College students

| The regression equation is I = - 0.0435 + 0.0268 KAI_SD | | | | |
|---|---|---|---|---|
| Predictor | Coef | SE Coef | T | P |
| Constant | - 0.0435 | 0.0896 | - 0.49 | 0.639 |
| KAI_Range | 0.0268 | 0.0104 | 2.59 | 0.029 |
| S=0.106912 | R- Sq = 42.7% | R- Sq(adj)= 36.3% | | |

Table 9. Regression of ΔI on KAI_SD for Graduate students

| The regression equation is I = 0.0441 + 0.00491 KAI_SD | | | | |
|---|---|---|---|---|
| Predictor | Coef | SE Coef | T | P |
| Constant | 0.0441 | 0.0463 | 0.95 | 0.441 |
| KAI_Range | 0.0049 | 0.0045 | 1.10 | 0.386 |
| S=0.0608381 | R- Sq =37.7% | R- Sq(adj)= 6.5% | | |

Regression analysis was performed by ΔI on the grouped KAI full range or standard deviation. The results show that the P value of the college students is significant and the p value of the graduate students is not significant. This means that the hypothesis at the beginning of the study is correct, that is, in a group, if the members contain members with different cognitive styles, it is helpful to stimulate the creativity of the team. As for the graduate students, there are several reasons why the analysis result was not significant.

1. The number of samples is insufficient, and the number of groups tested in this class is too small to achieve effective statistical analysis.

2. In the process of systematic innovation tool teaching, the KAI score differences of the master's class are relatively homogenous, and there is no significant difference to verify the relationship between the KAI score deviation on ΔI.

Table 10. The ΔI for each group

| ΔI | class |
|---|---|
| 0.5 | college |
| 0.1 | college |
| 0.2 | college |
| 0.14 | college |
| 0.03 | college |
| 0.16 | college |
| 0.13 | college |
| 0.01 | college |
| 0.25 | college |
| 0.12 | college |
| 0.26 | college |
| 0.05 | graduate |
| 0.01 | graduate |
| 0.14 | graduate |
| 0.13 | graduate |

The results showed that the P value of 0.106 (>0.05) was not significant, indicating that the learning effects between classes show without difference.

The results of the hypothesis 3 did not achieve the expected results, but there was a significant difference in the ΔI value score. The ΔI value score of the university department is higher than 0.2 in four groups, and the score difference of the master class has a maximum score of only 0.14, which is not effective. The reason for the result of this study is that the number of samples in the master's degree program is insufficient to achieve an effective statistical analysis.

## Conclusion

This study first defines each person's cognitive style with the KAI scale. Students are asked to solve problems and score in groups before and after the course. The results were found as follows.

Systematic innovation tools can indeed help the student community to increase their creativity.

In the case of team problem solving, team members with different types of cognitive styles in the group contribute to the improvement of creativity.

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