**Research Note**

**Comparative Analysis of Different Creativity Tests for the Prediction of Students’ Scientific Creativity**

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**Abstract**

This study aimed to explore different scientific creativity tests’ prediction of students’ science performance and domain-general creativity abilities. Two scientific creativity tests were chosen: the “Scientific Creativity Test” and the “Creative Scientific Ability Test (C-SAT)”. The Science Performance Test (SPT) and Domain-General Creativity Test (DGCT) were also adapted to allow a check of the correlation between students’ scientific creativity, science performance, and general creativity. Sixty junior high school students participated in this study by taking these four tests. Each test needed to be completed within 30 minutes, and the interval between each test was 2 weeks. The results showed that both the students’ science performance and domain-general creativity could reflect their performance of scientific creativity better in the scores of the “Scientific Creativity Test” than in those of the C-SAT. Limitations are discussed.

*Keywords*: Prediction, Scientific Creativity, Scientific Creativity Test

A Comparative Analysis of Different Creativity Tests for the Prediction of Students’ Scientific Creativity

Creativity can be used to solve problems in novel and useful ways (Guildford, 1950; Huang, Peng, Chen, Tseng, & Hsu, 2017). In many countries, educators and researchers consider creativity as one of the most important educational aims and thus are making great efforts to enhance students’ creativity (Bermejo, Ruiz-Melero, Esparza, Ferrando, & Pons, 2016; Shi, Cao, Chen, Zhuang, & Qiu, 2017).

Recently, an increasing number of scholars have argued that creativity is domain-specific, and have mentioned that scientific creativity involves domain-general creativity and scientific background knowledge (Amabile, 1996; Ayas & Sak, 2014; Csikszentmihalyi, 1996; Hu & Adey, 2002; Sternberg & Lubart, 1992). A set of tests that is often used to assess humans’ domain-general creativity is Torrance Tests of Creative Thinking (TTCT; Torrance, 1965, 1980, 1990). On the other hand, scientific background knowledge relates to the individual’s scientific knowledge and skills, whereas scientific creativity combines two factors, general creativity and scientific knowledge, which could be assessed by a domain-general creativity test or a scientific knowledge test. Those creativity tests should consider patterns of scores in different domains, and interpret their strengths and weaknesses (Kaufman & Baer, 2006).

In order to assess students’ scientific creativity abilities, several scientific creativity tests have been developed in recent years, such as the Scientific Creativity Test developed by Hu and Adey (2002) and the Creative Scientific Ability Test (C-SAT) developed by Ayas and Sak (2014). Although these two tests are both used to assess students’ scientific creativity, their theoretical paradigms and philosophies of science learning differ.

The Scientific Creativity Test (Hu & Adey, 2002) applies seven open-ended questions to assess students’ scientific creativity. Those questions combine science and creativity components. For example, the first question is “Please write down as many as possible scientific uses as you can for a piece of glass” (Hu & Adey, 2002). Students need to answer this question by considering the science characteristics of a piece of glass and by using their association or divergent thinking skills. The theoretical paradigm in the Scientific Creativity Test regards “divergent questions with a science component” as scientific knowledge. Moreover, the philosophy of science learning in the Scientific Creativity Test is that summative assessment could be regarded as students’ learning performance (Illeris, 2009; Oyao, Holbrook, Rannikmäe, & Pagunsan, 2015) and assumes that the students could integrate their scientific knowledge and domain-general skills in their mind, and show the integrated performance by external representations (Cowley & Vallée-Tourangeau, 2017).

On the other hand, the Creative Scientific Ability Test (C-SAT; Ayas & Sak, 2014) was designed to include five open-ended questions to assess students’ scientific creativity. Differing from the Scientific Creativity Test, those five questions in C-SAT are more focused on the science content knowledge and the science process skills such as observing, measuring, experimenting, and processing data (Citradevi, Widiyatmoko, Khusniati, 2017; Guo & Yang, 2012; Hodosyová, Útla, Vanyová, Vnuková, & Lapitková, 2015). For example, the first question in the C-SAT is as follows (Ayas & Sak, 2014):

“Subtest 1: the fly experiment”

The purpose of this task is to measure fluency, flexibility and creativity in hypothesis generation in the area of biology. This problem presents a figure of an experiment designed by a researcher. Students are required to generate as many hypotheses as they can think of that the researcher might test.”

This question asks students to answer a biology question by using science processing skills. The theoretical paradigm in the C-SAT is that scientific creativity is used for solving science problems. Its philosophy of science learning is that students’ learning performance will be shown in the formative assessment (Illeris, 2009; Oyao, Holbrook, Rannikmäe, & Pagunsan, 2015) and it regards that students’ scientific creativity could only be shown in the processing of inquiry (Ayas & Sak, 2014).

Which test better reflects students’ scientific creativity? The aim of this study was to answer this question by exploring the predictive power of the different scientific creativity tests. In this study, the correlations among different scientific creativity tests, a science performance test and a domain-general test, were examined as predictors of the students’ performance of scientific creativity. The core concept of the research was that a higher correlation between scientific creativity and science performance, and between scientific creativity and domain-general creativity could be indicated as a better predictor of students’ scientific creativity.

**Method**

**Participants**

This study was conducted at an urban junior high school in southern Taiwan. There are 240 11th-grade students in this school, of whom 60 were randomly selected to participate in this study. All of the 240 students’ school numbers were keyed into a computer, and 60 students (n = 60, 32 males, 28 females; mean age ± SD = 14.2 ± 2.0 years) were chosen by random number generator. Half of them (N=30) were social science majors (N=30) and the others are science and engineering majors. All participants were asked to complete the four tests, that is, the Scientific Creativity Test, the C-SAT, the SPT, and the DGCT.

**Instruments and Procedure**

***Instruments*** Four tests were adapted in this study: the Scientific Creativity Test (Hu & Adey, 2002), the Creative Scientific Ability Test (C-SAT; Ayas & Sak, 2013), the Science Performance Test (SPT), and the Domain-General Creativity Test (DGCT; Wu, Chen, & Lin, 1999). The items for the SPT were chosen from the Basic Competence Test for Junior High School Students in Taiwan. Figure 1 shows the research design of this study.

<Figure 1>

*Figure 1.* Inter-Relation of the Different Tests of Creativity Studied

As can be seen in Figure 1, science knowledge and creativity change dynamically in different situations, but scientific creativity always occurs simultaneously.

The details of the four tests are as follows:

**Scientific creativity test.** In Hu and Adey’s research, the reliability of the Scientific Creativity Test reached Cronbach’s α .89. In this study, the test was translated into Chinese, and the revised reliability reached Cronbach’s α .87.

**Creative scientific ability test (C-SAT).** The C-SAT was developed by Ayas and Sak (2013), and in their study, the reliability reached Cronbach’s α .84. This study referred the concepts of C-SAT and developed the contents of test. Besides, the figures illustrating the science concepts were also drawn for use in this study to make the students feel more familiar with them based on their learning in Taiwan. The revised reliability reached Cronbach’s α .98.

**Science Performance Test (SPT).** The SPT was developed for this study and included 20 items comprised of six items related to biology, eight items to physics, and six items to chemistry. These items were chosen for this study from the Basic Competence Test for Junior High School Students in Taiwan from 2012 to 2016. The test consists of multiple-choice style questions, meaning that each item has only one correct answer. The total score for this test is 100 points, with each item worth 5 points. The participants scored 5 points when they chose the correct answer, but 0 points when they chose an incorrect answer. The reliability of the SPT reached KR20 .70 and the average index of difficulty was .40. The average index of difficulty was calculated from the mean of the total item difficulty index of the SPT. Each item difficulty index was calculated using the following formula (NAER, 2000):

P=R/N\*100% (P means index of difficulty; R means the number of students who got the correct answer; N means the total number of students who took this test).

In this study, the SPT was designed as a multiple-choice test since this test was used to detect the participants’ science performance, not their divergent thinking. In other words, the correlation between the participants’ science background knowledge and their scientific creativity would be detected by SPT.

**Domain-general creativity test (DGCT).** The DGCT was developed by Wu, Chen, and Lin (1999) in Taiwan. There are two open-ended questions in this test requiring one written and one drawn response. In Wu, Chen, and Lin’s research, the reliability reached Cronbach’s α .93. In this study, the renewed reliability reached Cronbach’s α .91.

All participants needed to complete the four tests, and each test needed to be completed within 30 minutes. The interval between each test was 2 weeks.

**Results**

In this study, all data were analysed using SPSS version 22.0. Pearson’s correlation and regression statistical analysis were used to analyse the collected data.

**<Table 1>**

The results in Table 1 show that the scores of the Scientific Creativity Test had a significant but moderate correlation with the scores of SPT and a significant higher correlation with the scores of DGCT. This finding indicates that the Scientific Creativity Test could reflect students’ general creativity more than their science knowledge performance. On the other hand, the results in Table 1 show that the scores of the C-SAT had a significantly lower correlation with the scores of SPT. Furthermore, there was no significant correlation with the scores of the C-SAT and the DGCT. This was a surprising finding.

To better understand the degree of prediction of the two different creativity tests on science performance and domain-general creativity, stepwise multiple regression analysis was used in this study. First, the scores of the SPT and the DGCT were regarded as the independent variables, and the scores of the Scientific Creativity Test as the dependent variable (see Table 2).

**<Table 2>**

The results listed in Table 2 show that the DGCT had a significant main prediction, with 47% explanatory power and 46% adjusted explanatory power to predict the students’ performance on the Scientific Creativity Test. Moreover, the integrated independent variable which is involved in the SPT and the DGCT had a significant main prediction, with 52% explanatory power and 52% adjusted explanatory power to predict the students’ performance on the Scientific Creativity Test. In short, both the students’ science performance and domain-general creativity could predict their performance of scientific creativity, with domain-general creativity having higher prediction.

**Discussion**

Qian and Plucker (2018) mentioned that domain specificity or domain generality is one of the most important concerns regarding the nature of creativity. In the present study, the stepwise multiple regression equations of the Scientific Creativity Test and the C-SAT were as follows:

Scientific Creativity Test =.59× “DGCT” +.27× ”SPT” (1)

C-SAT =.30× “DGCT” +(-.05)× ”SPT” (2)

DGCT: Domain-General Creativity Test

SPT: Science Performance Test)

These equations mean that both the students’ science performance and domain-general creativity could reflect their performance of scientific creativity better in the scores of the Scientific Creativity Test than in those of the C-SAT. To be more precise, with respect to the creativity tests studied, the findings indicate that the scores of the C-SAT could not reflect students’ science performance or creativity.

The possible reasons why the scores of the C-SAT had a lower correlation with the scores of SPT might be the different outcomes of students’ science performance. The scores of the SPT and the Scientific Creativity Test were measured using summative assessment, while the measuring paradigm of the C-SAT was focused on formative assessment. The research on PISA 2015 mentioned that while many students could get higher scores on the science performance test using summative assessment, over half of them had never designed any scientific experiment before (OECD, 2015). This finding might also indicate that the questions of the Basic Competence Test for Junior High School Students in Taiwan from 2012 till 2016 could not detect students’ science processing skills.

In addition, there might be three possible reasons why the scores of the C-SAT had no significant main effect for correlation with the scores of the DGCT. First, the construct of C-SAT is more science-related, while DGCT is less to science content knowledge. If this is true, the results implied that teachers need to detect students’ scientific creativity carefully and more in relation to their educational purposes. Second, the participants in this study might have been unable to exhibit their creativity in answering the science questions in the C-SAT. Third, domain-general creativity may have been less used in the participants’ science reasoning process.

Ayas and Sak (2014) claimed that scientific creativity is more unidimensional than general, and they assumed that students’ domain-specific knowledge could be utilized in solving problems in each sub-dimension of the C-SAT. However, the findings of this study do not support these claims. In addition, Ayas and Sak (2014) assumed that most students may possess general scientific knowledge only in solving science problems in the C-SAT. Unfortunately, in this study, the results show that the students’ scientific creativity could not reflect their general scientific knowledge either.

The results imply that the students in this study did not exhibit general creativity in solving science problems, possibly because they lacked sufficient reasoning process skills or background knowledge. Besides, teachers need to choose the adaptive tests which are in line with the educational purposes to detect students’ performances. Furthermore, since the socio-cultural variable might be an important factor influencing the results, it is suggested that further studies investigate this issue in more depth and consider cross-cultural differences.

There are some limitations to this research. The participants were from only one school in southern Taiwan, and so the findings of this study should be interpreted with caution. Besides, the nature of science is extensive. The Science Performance Test could not include all of the definitions of science.

**References**

Amabile, T. (1996). *Creativity in context*. Boulder, CO: Westview Press.

Ayas, M. B., & Sak, U (2013). Creative Scientific Ability Test (C-SAT): A new measure of scientific creativity. *Psychological Test and Assessment Modeling, 55*(3), 316-329.

Ayas, M. B., & Sak, U (2014). Objective measure of scientific creativity: Psychometric validity of the Creative Scientific Ability Test. *Thinking Skills and Creativity, 13*, 195-205.

Bermejo, M., Ruiz-Melero, M., Esparza, J., Ferrando, M., & Pons, R. (2016). A New Measurement of Scientific Creativity: The Study of its Psychometric Properties. Annals Of Psychology, 32(3), 652-661.

Citradevi, C. P., Widiyatmoko, A., & Khusniati, M. (2017). The effectiveness of project based learning (PjBL) worksheet to improve science process skill for seven graders of junior high school in the topic of environmental pollution. *Unnes Science Education Journal, 6*(3), 1677-1685.

Cowley, S. J., & Vallée-Tourangeau, F. (2017). Cognition beyond the brain-computation, interactivity and human artifice. New York. NY: Springer.

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention.* New York. NY: Harper Collons.

Guilford, J. P. (1950). Creativity. *American Psychologist, 5*, 444-454.

### Guo, S. & Yang, Y. (2012). Project-Based Learning: An Effective Approach To Link Teacher Professional Development And Students Learning. J*ournal of Educational Technology Develpoment and Exchange, 5*(2), 41-56.

Hodosyová, M., Útla, J., Vanyová, M., Vnuková, P., & Lapitková, V. (2015). *The development of science process skills in physics education*. Paper presented in the 5th World Conference on Learning, Teaching and Educational Leadership, WCLTA(2014), Prague.

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of* *Science Education, 24*(4), 389-403.

Huang, P.-S., Peng, S.-L., Chen, H.-C., Tseng, L.-C., & Hsu, L.-C. (2017). The relative influences of domain knowledge and domain-general divergent thinking on scientific creativity and mathematical creativity. *Thinking Skills and Creativity, 25*, 1-9.

### Illeris, K. (2009). Competence, learning and education: How can competences be learned, and how can they be developed in formal education? In K. Illeris (ed.) *International perspectives on competence development: Developing skills and capabilities* (pp. 83-98). New York: Routledge.

### Kaufman, J. C. & Baer, J. (2006). Intelligent testing with Torrance. *Creativity Research Journal, 18(*1), 99-102.

Lubart, T. I. (1994). Creativity. In R. J. Sternberg(Ed.), *Thinking and Provlem Sloving*. New York: Academic Press, pp. 289-332.

National Academy for Educational Research (NAER). (2000). Item Difficulty Index. 20160422Retrieved from http://terms.naer.edu.tw/detail/1315295/.

Ochse, R. (1990). *Before the gates of excellence: The determinants of creative genius.* New York: CambridgeUniversity Press.

Organization for Economic Co-operation and Development (OECD). (2015). OECD. StatExtracts-OECE Health Statistics. 20171220Retrieved from

<http://www.oecd-ilibrary.org/social-issues-migration-health/data/oecd-health-statistics_health-data-en>.

### Oyao, S. G. Holbrook, J., Rannikmäe, M., & Pagunsan, M. M. (2015). A competence-based science learning framework illustrated through the study of natural hazards and disaster risk reduction. *International Journal of Science Education, 37*(14), 2237-2263.

### Qian, M. & Plucker, J. A. (2018). Looking for renaissance people: examining domain specificity-generality of creativity using item response theory models. *Creativity Research Journal, 30*(3), 241-248.

### Shi, B., Cao, X., Chen, Q., Zhuang, K., & Qiu, J. (2017). Different brain structures associated with artistic and scientific creativity: a voxel-based morphometry study. *Scientific Reports, 7*(4), 1-8.

### Siew, N. M., Chong, C. L., & Chin, K. M. (2014). Developing a Scientific Creativity Test for Fifth Graders. *Problems of Education in the 21st Century, 62*, 109-123.

### Sternberg, R. J., & Lubart, T. I. (1992). Buy low and sell high: An investment approach to creativity. *Current Directions in Psychological Science, 1*(1), 1-5.

Sternberg, R. J., & Lubart, T. I. (1999). The concept of creativity: Prospects and paradigm. In Sternberg, R. J. (Ed.), *Handbook of Creativity* (pp.3-15). NY: Cambridge.

Torrance, E. P. (1965). Scientific views of creativity and factors affecting its growth. *Daedalus, 94*, 663-664.

Torrance, E. P. (1980). Growing Up Creatively Gifted: The 22-Year Longitudinal Study. *The Creative Child and Adult Quarterly, 3*, 148-158.

Torrance, E. P. (1990). *Torrance Tests of creative thinking. Figural forms A and B: directions manual*. Bensenville: Scholastic Testing Service.

Wu, J.-J., Chen, J.-C., & Lin, W.-W. (1999). *A brief introduction to the scale of creativity*. The article of the conclusion of a case applied for the study of National Science Council, Kaohsiung.

**Figure Legend:**

Figure 1 Inter-Relation of the Different Tests of Creativity Studied

Science Knowledge

Creativity

Scientific Creativity

Domain-

General Creativity Test (DGCT)

Science Performance Test

(SPT)

Scientific Creativity Test (Hu & Adey, 2002)

Creative Scientific Ability Test (C-SAT) (Ayas & Sak, 2013)

Correlation

Correlation

**Table Legend:**

Table 1 The Pearson’s correlation analyses of all data from the four tests

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Tests | SPT | DGCT | Scientific Creativity Test | C-SAT |
| SPT |  | .39\*\* | .50\*\* | .20\* |
| DGCT | .39\*\* |  | .69\*\* | .28 |
| Scientific Creativity Test | .50\*\* | .69\*\* |  | .30\* |
| C-SAT | .20\* | .28 | .30\* |  |

### Note: N=60； \**p*<.05； \*\**p*<.01

Table 2 The Abstract of stepwise multiple regression analysis between the Scientific Creativity Test (dependent variable), the SPT, and the DGCT.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Independent variable | R | R2 | Adjusted R2 | R2 change | F change | *p* |
| DGCT | .68 | .47 | .46 | .47 | 41.94 | .000 |
| SPT & DGCT | .73 | .52 | .52 | .06 | 5.94 | .020 |