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# Applying Graphic Reasoning Simulation Tool to Explore the Scientific Creativity

**Hsi-Hsun Yang[a], Sheng-Kai Yin[*b]**
[a]*Department of Digital Media Design, National Yunlin University of Science & Technology Douliou, Yunlin, Taiwan*
[b]*Department of Digital Design, MingDao University, Pettow, ChangHua, Taiwan*
[*]corresponding author: ysk@mdu.edu.tw

**Abstract:** The purpose of this study is to investigate the effects of applying Graphic Reasoning Simulation Tool on sixth-grade students' learning of scientific creativity. The participants included 90 elementary students of sixth-graders of four classes in central Taiwan. A quasi-experimental design is adopted as the methodology. The two classes carry Graphic Reasoning Simulation Tool for the experimental group, and the other two carry traditional teaching for the control group. The instruments included questionnaires of assessment of scientific creativity. The results of the study are presented as follows: the experimental and control group in the scientific creativity ability, reflects no significant to learning effect. The reason for the needs to improve more functionally of Graphic Reasoning Simulation Tool, so as to achieve the main spirit of scientific creativity.

**Keywords:** Scientific Creativity, Creativity, Graphic Reasoning Simulation Tool, Graphics Reasoning, Line Symmetrical graphics

## 1. Introduction

Origami involves creating different shape and structure through repeated folding of a piece of planar paper. The series of spatial structure changes is in fact the easy observation target for the learner. The shape that is formed out of origami integrates properties like hand-eye-brain coordination, spatial figures, dimensional space, and arts. It also represents a simple and interesting teaching activity for the development of scientific exploration and reasoning skills (Yang, Yin & Chen, 2014).

The shape that is formed out of origami integrates properties like hand-eye-brain coordination, spatial figures, dimensional space, and arts. Origami activity can be seen as the realization of scientific creativity because it requires the utilization of professional concepts like mathematics, geometry, spatial graphics, and algebra. Also, the cornerstone of scientific creativity is the realization of scientific knowledge and skills in works or creations. Tang (1986) discovered that although the structure of arts activity and scientific activity is similar, there are differences in essence and origin, and especially the former. Yager (1996, 2000) stressed that unleashing scientific creativity can only be achieved through the process of scientific exploration and reasoning of scientific concepts with a scientific mind basing on the core issues of scientific concepts and scientific processes. Further, scientific creativity can be applied to the problem-solving in our daily lives. The premise of scientific creativity is established on more rigorous scientific knowledge backgrounds and methodologies. This definition underscores the domain specific nature of scientific creativity in terms of the background knowledge of science. Vartanian, Martindale and Kwiatkowski (2003) pointed out that the realization of scientific creativity is the objective of scientific exploration learning. The purpose of scientific exploration learning is to utilize structured deduction methods to train students, encourage them to learn proactively, help students understand the theorems and rules in order to solve problems, and then plan according to the discovered data. It is generally believed that explorative learning is beneficial towards enhancing students' scientific creativity.

Spatial ability serves a pivotal role in the learning of mathematics and geometry. Some scholars believe that spatial ability denotes the ability to rotate mental representations of two-dimensional and three-dimensional objects as it is related to the visual representation of such rotation within the human mind. Spatial ability also refers to the ability to capture the cognitive process and surrounding relationships (McGee, 1979; Linn & Petersen, 1985). The purpose of this study is to explore the relationship between spatial transformation and scientific creativity.

We developed two systems: first is Line Symmetrical Graphics; and second is Graphics Reasoning. We collectively call the two systems "Graphic Reasoning Simulation Tool." We use the system to do 6 teaching sessions that determine whether or not Grade 6 students' scientific creativity can be improved.

## 2. Methodology and Instrumentations

This study adopts a quasi-experiment approach. There are two groups: experiment and control group. The Experiment group received 6 teaching sessions of Graphic Reasoning Simulation Tool - Line Symmetrical Graphics and Graphics Reasoning, and the control group was not administrated any teaching activity. Each session is 40 minutes. After the experiment, both groups were given a post-test of the "assessment of scientific creativity" and "geometric reasoning effectiveness evaluation". Samples of this research were taken from 4 classes of Grade 6 students in central Taiwan. The experiment group consisted of 44 students and the control group consisted of 46 students. The research instrumentations employed in this experiment are explained below.

### *2.1 Graphic Reasoning Simulation Tool*

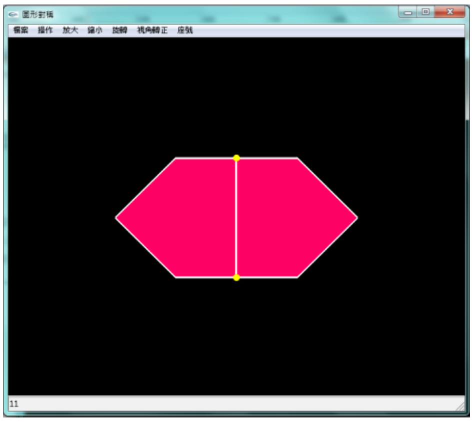

Figure 1. Screenshots of Line Symmetrical graphics - Graphic Reasoning Simulation Tool

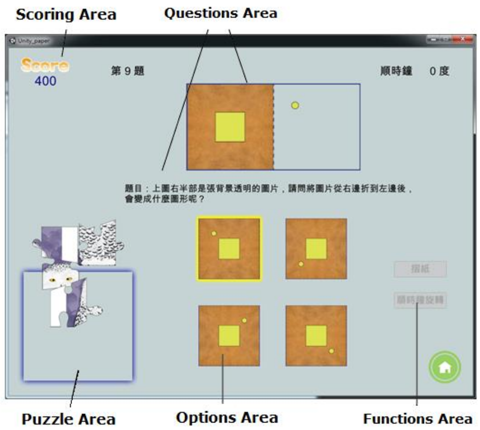


Figure 2. Screenshots of Graphics Reasoning - Graphic Reasoning Simulation Tool

In the fig. 1, the major purpose of the Line Symmetrical Graphics is to help students learn about line symmetry principles through a digital system, as well as learning by doing and leaning by self-observation through actual operation and exploration. In particular, students only have to follow the basic principles of "identify a straight line in a graphic, double fold along the straight line and so you can achieve entire overlap, and then this geometric graphic is a symmetrical graphic." "Learning by doing" is the most important element in a digital system. Line Symmetrical Graphics is a modified and extended system from Open Media Laboratory of Chukyo University at Japan (http://www.om.sist. chukyo-u.ac.jp /research/ origami/).

In the fig. 2, Graphics Reasoning is the second system that was developed by the Unity game engine. The major purpose of the system is to train students: relative graphic position, spatial reasoning skill and moving and rotation skills. A picture with a transparent background is placed at the right hand side of the screen (e.g. Questions Area of fig. 2). The dashed lines in the middle represent folded lines. After the picture on the right is folded to the left so that the right and left overlap, students are asked what type of graphic would emerge. This system has two versions, Game version and Timed version. The Game version is designed for students' use in exercises, and Timed version is for testing use.

### *2.2 Assessment of scientific creativity*

According to Guilford (1967), creativity is characterized by elaboration, flexibility, originality, ideational spontaneity, and flexibility. For elementary students, the former three are more apparent. Therefore, we measure creativity with the dimensions of elaboration, flexibility, and originality. The instrument employed by this study contains three dimensions and a score of 20 is assigned to each dimension. Scoring is assessed by three experts. If an answer conforms to the characteristics of each criterion, a score of 1 is awarded. If the three experts' score of each item differ by less than 3, then the mean score is recorded as the final score. If the difference is more than three, then the final score is determined by other experts.

## 3. Results and data analysis

After 6 teaching sessions, the researcher analyzed the "Assessment of scientific creativity" score of the experiment group and the control group. To avoid bias among the expert scoring, the "Assessment of scientific creativity" was subject to a reliability test. The correlation coefficients of the three experts were between 0.879 and 0.901, and the $p$-value reached the significant level of 0.01. Therefore, the expert scoring of this study has good consistency. The "Assessment of scientific creativity" score was then examined. The mean score of the experiment group was 39.57 (perfect score = 60), SD of 7.92. The mean score of the control group was 38.22, SD of 8.92. Also, the $t$-value of the mean score of the two groups was 0.75 (p=-0.228), which was insignificant.

Statistical results showed that "Line Symmetrical Graphics" and "Graphical Reasoning" learning activities did not sharpen the scientific creativity of students in the experiment group. The major reasons include: 1). The time allotted to using the Graphic Reasoning Simulation Tool is short and the teaching activity is not adequate to cause a difference in students' scientific creativity; 2). "Line Symmetrical Graphics" and "Graphical Reasoning" emphasized reinforcing the concepts of geometry equality, spatial concepts, and relative position. Therefore, these items are not enough to influence students' scientific creativity.

## 4. Summary

The major purpose of this research is to examine the effect of "Line Symmetrical Graphics" and "Graphical Reasoning" on students' scientific creativity. After 6 teaching sessions, experiment group students did not have a significantly higher score than control group students in terms of elaboration, flexibility, and originality. The major reason is that the teaching activity is not long enough to cause difference in students' scientific creativity. Generally speaking, it takes time to nourish scientific creativity, and the teaching materials used by this study are unable to alter students' scientific creativity in a short time. In addition, the Graphic Reasoning Simulation Tool can only enhance students' conceptualization in geometrical equality, spatial concepts, and relative position. These concepts are not enough to stimulate the elaboration, flexibility, and originality dimensions of students' scientific creativity. We suggest extending the teaching activity to 15-20 hours as well as enhancing the Graphic Reasoning Simulation Tool. We believe within the explorative space of Graphic Reasoning Simulation Tool, children's scientific creativity performance can be fostered.

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