Mathematics and Art: Thai Students' Design with The Geometer's Sketchpad

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Abstract

The purpose of this research study is to explore the connection of mathematics, art and technology in the context of school mathematics. Data of the study were collected from 6 sample upper secondary schools in Thailand and the students were 16 year-old.

Research findings show that through mathematics project-based learning approach and the use of the Geometer's Sketchpad (GSP), the students were able to illustrate the connection of geometry patterns, functions and art.

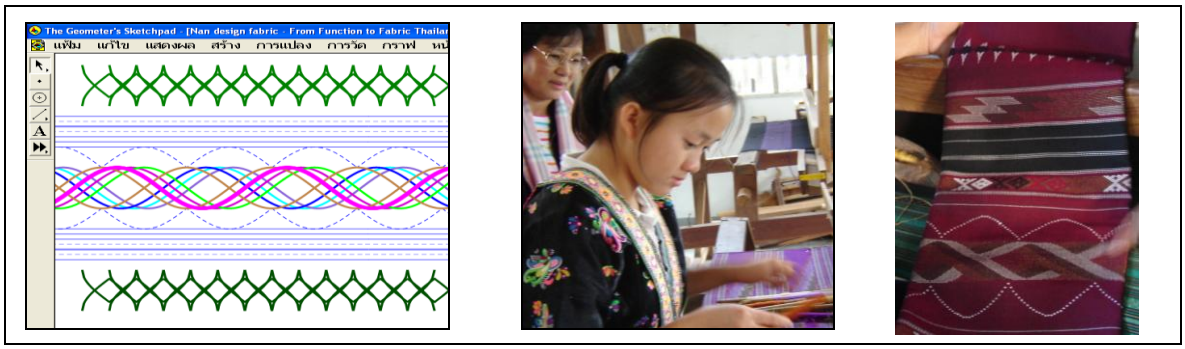

Figure 1. Thai students' mathematics and art designed, traditional looms and fabric

Based on the students' interviews they revealed that with GSP they were able to visualize and create graphical representations, which will enable them to develop their mathematical thinking skills, concepts and constructing mathematics knowledge. The students had fun in creating variety of graphs of functions which they can not do by drawing on graph paper. In addition, there are evidences to show Thai students' abilities in designing and connecting mathematics and art to real life outside the classroom and commercial products, such as weaving, patterning of broomstick, ceramics design, brooch and silver drinking bowl.

Figure 2. Trigonometric function designed for ceramic product

Keywords:

Thai Students' design, mathematics, art, the Geometer's Sketchpad, project-based learning, and commercial products

Introduction

The purpose of this research study is to explore the connection of mathematics project-based learning approach and the use of technology in the context of school mathematics in Thailand. Nowadays there are various information and communication technology which can be used effectively in mathematics class. One of them is a dynamic mathematics software named *the Geometer's Sketchpad (GSP).* GSP was introduced in Thailand since the year 2000. In year 2004 GSP was translated into Thai language and used widely in Thailand. More than 1,000 mathematics teachers were trained to use GSP as a tool in their mathematics classes.

Mathematics Project-based Learning

Mathematics project-based learning approach is employed in secondary schools in Thailand. This approach is one of the learning activities that shift away from the traditional classroom practices which are isolated, and teacher-centered. This approach emphasizes learning activities that are long-term, interdisciplinary, student-centered, and integrated with real world tasks to enhance learning. Students engage in project-based learning generally work in cooperative groups for extended periods of time, and seek out multiple sources of information (Oon - Seng Tan, 2003). According to Savin-Baden, M & Howell Major (2004) the project-based learning promotes collaboration among students, between students and the teacher, and between students and the community as well. Mathematics project-based learning approach provides opportunities for students to apply and integrate the content of different subject areas such as mathematics, arts and the use of technology to the production process. Thai Students have to design and develop their mathematics skills that relate to their daily lives. This idea was support by Masingila, J (1993), she said that it is her contention that the gap between doing mathematics in school situations and doing mathematics in out-of-school situations can only be narrowed after much is learned about mathematics practice in the context of everyday life.

Empowerment Through Tools: The Geometer's Sketchpad

The Geometer's Sketchpad is one of the dynamic mathematics software that provides opportunities for students to investigate and discover mathematics concepts in particular geometric patterns, functions and graph of trigonometric functions. GSP empowers students to use their abilities to create graphical representation, to enable them in developing their mathematical thinking skills, concepts, and understanding. In using GSP students learn by exploring, investigating and discovering.

From Mathematics Classroom to Commercial Product

We all know that mathematics is involved in every pieces of goods/product such as size, shape and pattern. Through mathematics project-based learning approach and the use of GSP, students are able to explore mathematics concepts in particular geometric patterns, functions and graph of trigonometric functions in more details and make mathematics learning fun and challenging. In addition, the use of mathematics project-based learning approach enhances students in exploring and creating mathematics content to commercial product such as weaving, patterning of broomstick, ceramics design, brooch and silver drinking bowl.

Research

This research is a case study that emphasizes mathematics project-based learning approach and the use of the Geometer's Sketchpad (GSP). The main purpose of the study is to explore mathematics art and GSP using project-based learning approach in the context of school mathematics in Thailand and connecting to real life outside the classroom and commercial products.

Research Process

Data of the study were collected from sample schools in Education school year 2006 until July 2008 from Srisawat Witayakarn School in Nan province, and Kalang Nakorn Lampang School in Lampang province Thailand. The 16 year-old students were at Upper Secondary level. Mathematics teachers in the sample schools implemented GSP as a tool in their classes. The students used GSP in mathematics projects and worked together in small groups of three to four members.

In this study, the researcher collected data from various resources such as classroom observations, students' project reports, newspaper, and commercial products. Semi-structured interviews with the teachers and students were also conducted.

Research Questions

1. In what way GSP can be used as a tool in designing mathematics, art and mathematics project-based learning approach?
2. What are the effects of mathematics project-based learning approach using GSP towards students' attitudes in mathematics?

Research Findings

The research findings were based on the students' mathematics project reports, the researcher's classroom observations, and interviews. The students' works show how they used GSP as a tool in constructing functions, trigonometric functions and geometric patterns. The students implemented their works designs in mathematics to the commercial product.

Research Question 1: In what way GSP can be used as a tool in designing mathematics, art and mathematics project-based learning approach?

The summary of research findings and the examples of students' works are described as follows.

1) From Functions to Nan Fabric Designed by Students of Srisawat Witayakarn School, Nan Province.

Thai textile weaving was designed by the students of Srisawat Witayakarn School, Nan Province Thailand. The students applied knowledge on graph of functions and arts to create the patterns of Thai textile weaving design. The students enjoy using GSP to create the graphs of trigonometric function especially graph of sinθ, cosθ, arcsineθ, and arcos θ. They constructed more than 50 graphs of trigonometric functions and came up with the beautiful fabric design. Examples of the students' designs are shown in Figure 3, Figure 4, and Figure 5. The students then provided the names of their designs, Figure 3 is Kleau-Klun design, Figure 4 is Samukkee-Klomklew design, and Figure 5 is Klun-Obe-Kao design.

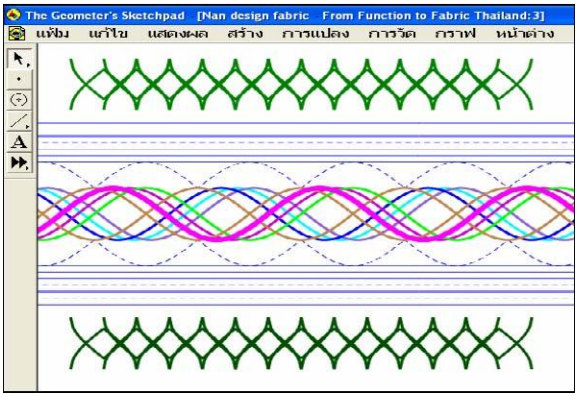

Figure 3. : Kleau-Klun design

The following functions are some examples of functions and trigonometric functions of Kleau-Klun design. The examples functions are shown as follows.

$$f(x) = b \times \cos^{-1}(|x+h|) + a;$$

$$g(x) = \cos^{-1}(|x+j|) + s;$$

$$h(x) = \cos^{-1}(|x+j|) + s;$$

$$s(x) = \cos^{-1}(|x+h|) + a;$$

$$w(x) = |\cos(x)|$$

Samukkee-Klomklew design is shown in Figure 4 below. The example functions and trigonometric functions of Samukkee-Klomklew design are shown as following:

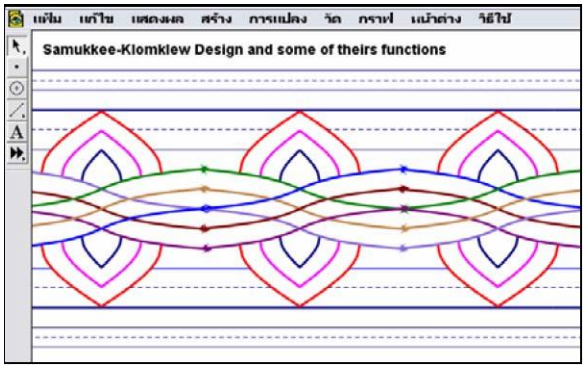

Figure 4. Samukkee- Klomklew design

$$f(x) = \log(x + \sqrt{1+x^2}) \qquad g(x) = \cos^{-1}(|x|) + 2.4$$

$$h_2(x) = -f(x); \qquad h(x) = 1.5\cos^{-1}(0.5|x|) + 2.6$$

$$f_2(x) = f(x) + 1; \qquad q(x) = 2\cos^{-1}(0.33|x|) + 2.8$$

$$g_2(x) = f_2(x) + 1; \qquad q_2(x) = h_2(x) + 1;$$

$$r_2(x) = q_2(x) + 1); \qquad h_4(x) = -g(x) + 2;$$

$$u_4(x) = -h(x) + 2; \qquad h_5(x) = -q(x) + 2;$$

2) From Trigonometric Function to Ceramic Designed by Students of Kalang Nakorn Lampang School, Lampang Province.

There are quite a number of Ceramic Factories in Lampang province. The students were assigned to do mathematics project which relevance with a famous product in their province. They employed knowledge learned on trigonometric and transformation in mathematics classes to design a pattern of ceramic. The following examples show how students used GSP in their mathematics project.

Ceramic design 1:

The students designed a pattern of ceramic and used GSP to construct functions ***f(x) = cos (a. x)*** as following:

- Using Graph menu to construct a parameter ***a***
- Enter function ***f(x) = cos (a. x)*** by
  - Choosing ***New Function*** from the *Graph menu*;
  - Enter ***a*** by clicking on parameter ***a*** on the sketch and click on keyboard ***x*** in the *New Function* dialog box then click *OK;*

- Select f(x) = cos (a. x) on the screen, then choose *Graph menu* and select *Plot Function*;
- Graph of f(x) = cos (a. x) appears on the screen as figured on your right;
- Construct Point ***A*** on graph of f(x) = cos (a. x)
- Using point ***A*** as a center and construct a circle with radius about 1 cm, and construct point B on this circle;
- Construct line CD parallel to x-axis
- Reflect point B across line CD to create point B′.

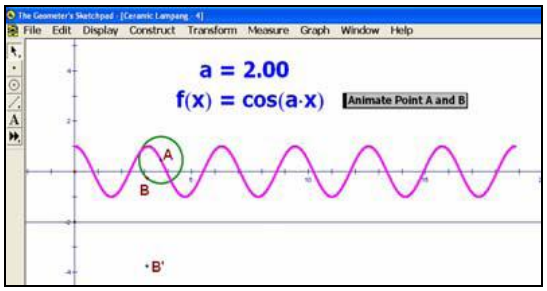

Figure 6. Graph of f(x) = cos (a. x)

- Select point ***B*** and point ***B′***, and Turn on *Trace points* menu
- Animate points ***A*** and ***B***.
- The traced pattern of point ***B*** and point ***B′*** will appear the same as figure on your right.

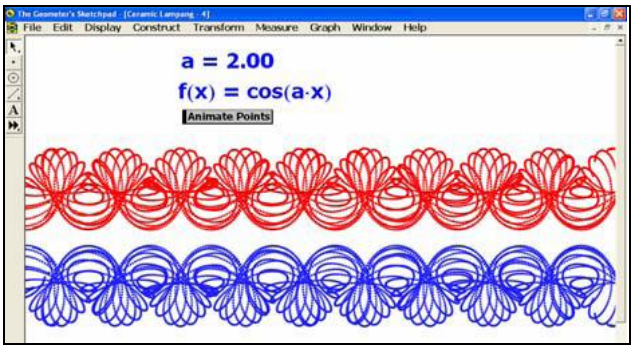

Figure 7. Pattern designed for Ceramic Product

Ceramic design 2: Sketch and investigate using new sketch of GSP

The students designed a pattern of ceramic and used GSP to construct functions ***f(x) =sin(a.x). cos (b.x) + sin (b.x)*** as following:

- Using Graph menu to construct parameters ***a*** and ***b*** and plot function *f(x) =sin(a.x). cos (b.x) + sin (b.x)* by choosing **Plot New Function** from *Graph menu*
- Construct Point ***A*** on graph of *f(x)*
- Using point ***A*** as a center and construct a circle with radius about 1 cm, and construct point ***B*** on this circle;
- Construct line ***CD*** parallel to x-axis
- Reflect point ***B*** across line ***CD*** to create point ***B′.***

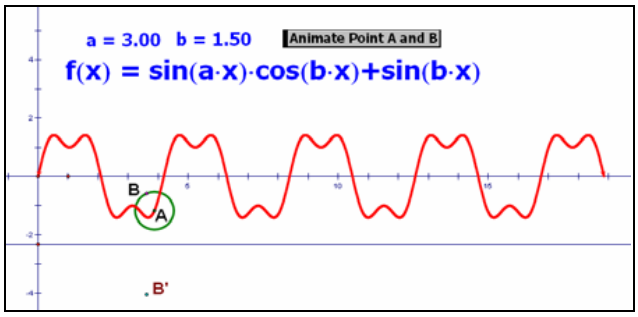

Figure 8: Graph of f(x) =sin(a.x). cos (b.x) + sin(b.x)

- Turn on Trace points for point ***B*** and point ***B′***,
- Animate points ***A*** and ***B***.
- The traced pattern point ***B*** and point ***B′*** will appear the same as figure on your right.

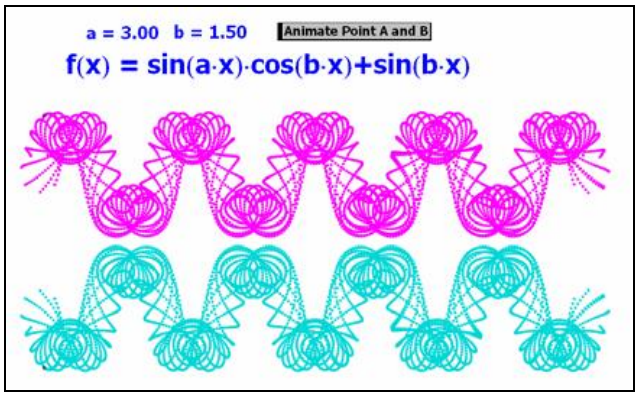

Figure 9. Pattern designed for ceramic product

3) From geometry in mathematics to brooch and silver drinking bowl designed by Students of Srisawat Witayakarn School, Nan Province.

The students of Srisawat Witayakarn School, Nan Province were assigned to do mathematics project which relevance to a product to be used in daily life. They applied knowledge learned on geometry, translation, reflection and symmetry topics in mathematics to create the patterns of brooch and design patterns for silver drinking bowl. The example of geometric and functions of design and photographs of these products are shown in Figure 10 and Figure 11.

The examples of functions of the design of brooch are as follows:

$f(x) = 1.5\sin^{-1}(x)$; $g(x) = -1.5\sin^{-1}(x-2)$; and $h(x) = -\sqrt{-(x-1)^2+4} - 2$

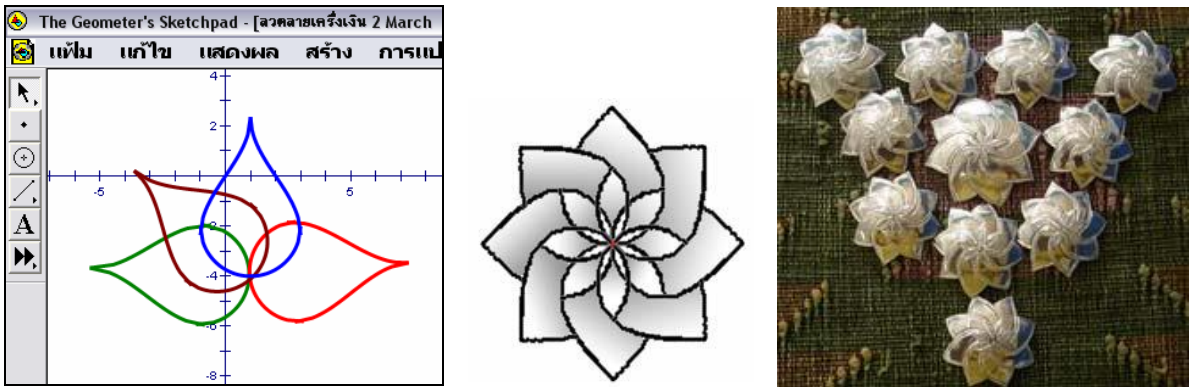

Figure 10. Pattern designed for brooch

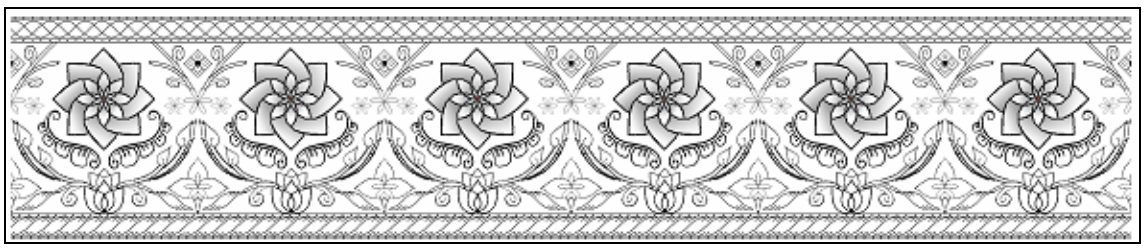

Figure 11. Pattern designed for silver drinking bowl

Figure 12. A silver drinking bowl commercial product

Research Question 2: What are the effects of mathematics project- based learning approach using GSP towards students' attitudes in mathematics?

Based on the findings, the researcher found out that the students in the sample schools can exhibit their relational understanding in mathematics which involves understanding structures and connections within concepts (Skemp, 1978). Results from students' semi-structured interview reveal that the after the students did their projects they liked to learn mathematics and they have more understanding on mathematical topics. The students can explain, know what to do and knew why they had to do.

In addition, the students revealed that with GSP they were able to visualize and create graphical representations, which will enable them to develop their mathematical thinking skills, concepts and understanding. The students had fun in creating variety of graphs of functions which they can not do by drawing on graph paper. The students explained that it was fun in learning mathematics by this method. It was better than work only from the exercises in mathematics textbook. Based on these evidences the students have acquired a positive attitude toward mathematics.

Conclusion

All illustrations are evidences to show the students' abilities in connecting mathematics and art with GSP to real life outside the classroom and commercial products, such as weaving, patterning, and ceramics design. It is clear that, with GSP students are able to visualize and create graphical representations to enable them to develop their mathematical thinking skills, concepts and understanding. This project can further facilitate learning among students establish useful connections in mathematics, particularly to life in the world outside classroom and to develop commercial products.

References

Bennett, D. (2002). *Exploring geometry with the Geometer's Sketchpad: Revised for use with Version 4.* CA: Key Curriculum Press.

Cuoco, A. & Curcio, F.(Eds.) (2001), *The roles of representation in school mathematics. 2001 Yearbook.* National Council of Teachers of Mathematics. Reston: VA

Kemp, Jerrold E. (1971) *Instructional Design: A Plan for Unit and Course Development.* Belmont, California: Fearon/Lear Siegler.

Khairiree, K. (2007). *Exploring Ethnomathematics with the Geometer's Sketchpad (GSP):* Thai Students' Weaving Projects. In Wei-Chi Yang, Tilak de Alwis & Jen-Chuan Chuan (Eds). Proceeding of the Twelfth Asian Technology Conference in Mathematics. (pp. 105-114). Mathematics and Technology, LLC: USA.

Masingila, J. (1993) *Connecting the Ethnomath of carpet layers with school learning*. In ISGEm Newsletter (International Study Group on Ethnomathematics) Volume 8 Number 2, May 1993.

Oon-Seng Tan (2003) *Problem-Based Learning Innovation: Using Problems to Power Learning in the 21st Century*. Singapore: Seng Lee Press

Savin-Baden, M. & Howel Major, C. (2004). *Foundations of problem-based learning.* England: SRHE and Open University Press Imprint

Scher, D.l & Rasmussen, S. (2009). *Spark! Teaching Mathematics with The Geometer's Sketchpad*. CA: Key Curriculum Press Emeryville

Skemp, R.R. (1978). Relational understanding and instrumental understanding. *Arithmetic Teacher*, 26(3), 9-15.

Students' mathematics project report (2008). *From mathematics and art to Nan: Silver commercial products*. Srisawat Witayakarn School, Nan Province Thailand.

Students' mathematics project report (2007). *Using GSP to design ceramic products*. Kalang Nakorn Lampang School, Lampang Province, Thailand.

Students' mathematics project report (2005). *From Function to Nan:Thai Weaving Textile* Srisawat Witayakarn School, Nan Province Thailand.

van Hiele, P.M., & van Hiele-Geldof, D. (1958). A method of initiation into geometry. In H. Freudenthal (Ed.), *Report on methods of initiation into geometry*. Groningen: Wolters.

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