How to use Dynamic Geometry Software in the Math Classroom.

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Abstract

Geometry, which Japanese junior high school students must study, is effective for teaching students mathematical reasoning and logical thinking. However, when they learn formal proof-problem solving for the first time, constructing the figures with compass and ruler poses particular problems.
Recently dynamic geometry software, like Cabri, is gaining popularity among math teachers in Japan. But many teachers use it only to explain the properties of figures that they have already constructed. If students use Cabri, instead of compass and ruler, for constructing figures, a major obstacle in geometry learning can be overcome.
Therefore, I allowed my students to construct figures using Cabri in math class. I observed the class for three years, and made the following observations. Students can learn to construct figures using Cabri more easily than was previously thought. Students became more motivated in their geometry studies when they could always construct figures to solve proof-problems. Students were able to come up with more of a variety of solutions for any given proof using Cabri than without using Cabri.
In this paper, I will discuss how Cabri can be used to overcome obstacles to learning geometry.

1. Introduction

Currently, Japanese teachers generally prepare figures before class, and show them to the students to help the students develop an understanding of properties of figures and of proofs in math class. This method is very efficient.
However, I think it is more effective for students to draw the figures by themselves, rather than only using prepared figures. I provide enough time for my students to draw figures by themselves in class. I found that Cabri is an effective tool because it’s easy to use, and students can develop an ability to construct figures using it. They enjoyed constructing figures. Then, they could easily modify and observe the figures. Moreover, we were surprised that students had very novel ideas. I think that studying using Cabri allows students to develop an ability to think mathematically, and cultivates creativity.

2. Purpose

(1) How students have a willingness to learn geometry and understand the necessity of proofs by using Cabri.

(2) How students gain logical and creative thinking skills after drawing figure themselves by using Cabri.

3. Methods

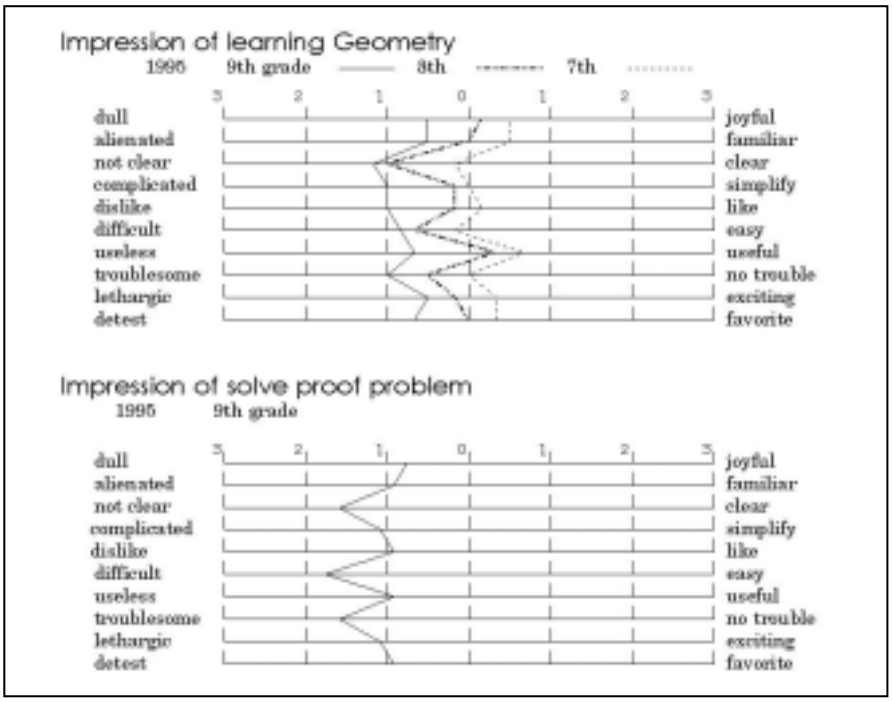
Junior high school students, from 7th grade to 9th grade (twelve to fifteen years old), were observed studying geometry using Cabri. Students were observed over a three-year period. Students used Cabri in the classroom 10 hours per year. When students used Cabri, they had enough time to draw figures. The observations were analyzed using qualitative data: a work sheet including students reasoning and comments; the figures which students drew on the computer, which were used to analyze the procedures students used for drawing; and interviews with students during class.

4. Students' Feelings towards Geometry (before using Cabri)

(1) Investigation of the impression of learning geometry

Before I started this study, I surveyed the students to find at their impressions of geometry. I conducted this survey on about 400 students (7^{th} to 9^{th}).

Following is a graph representing the results of this survey.



We learned that as students got older, their feelings about geometry became more negative.

(2) Investigation of solving proof problems

I presented the following proof solving problem to 9th grade students, without providing drawn figures. This problem is at an eighth grade level.

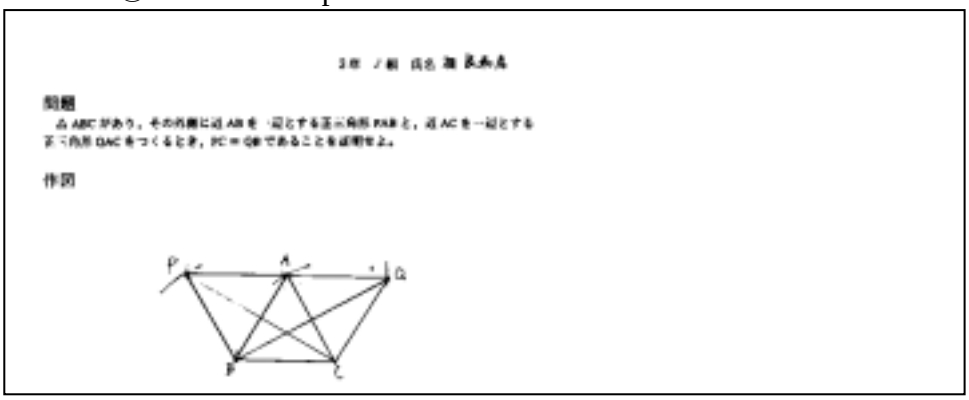
Problem

Make a triangle ABC. Then make an equilateral triangle PAB using segment AB as one side, and an equilateral triangle QAC using segment AC as one side.

Prove PC=QB

① Draw figures for solving this problem.

② Write the proof



Out of 36 students, only 6 students could complete this proof. I believed that there were two reasons for this.

First, students couldn't differentiate between the assumption and the conclusion.

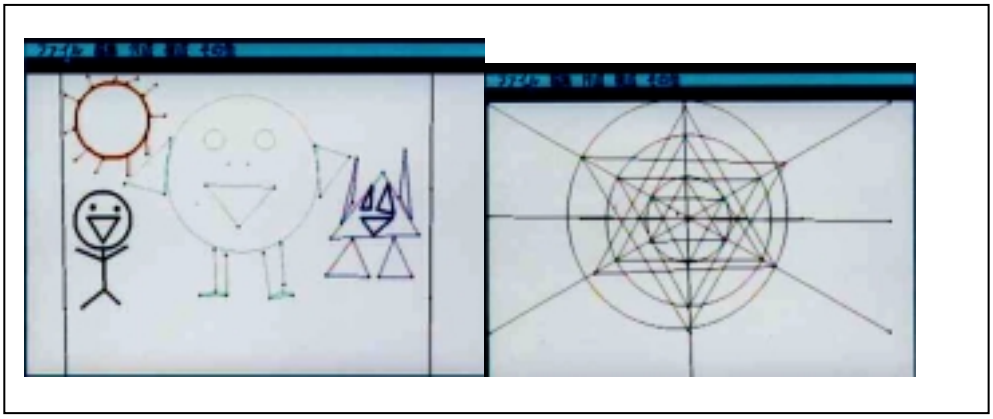
Secondly, when they tried to solve the geometrical proof problem, they thought only by drawn figures. When we proposed these problems many students drew triangle ABC as an equilateral triangle.

I thought drawing and modifying the figures using Cabri could overcome these problems.

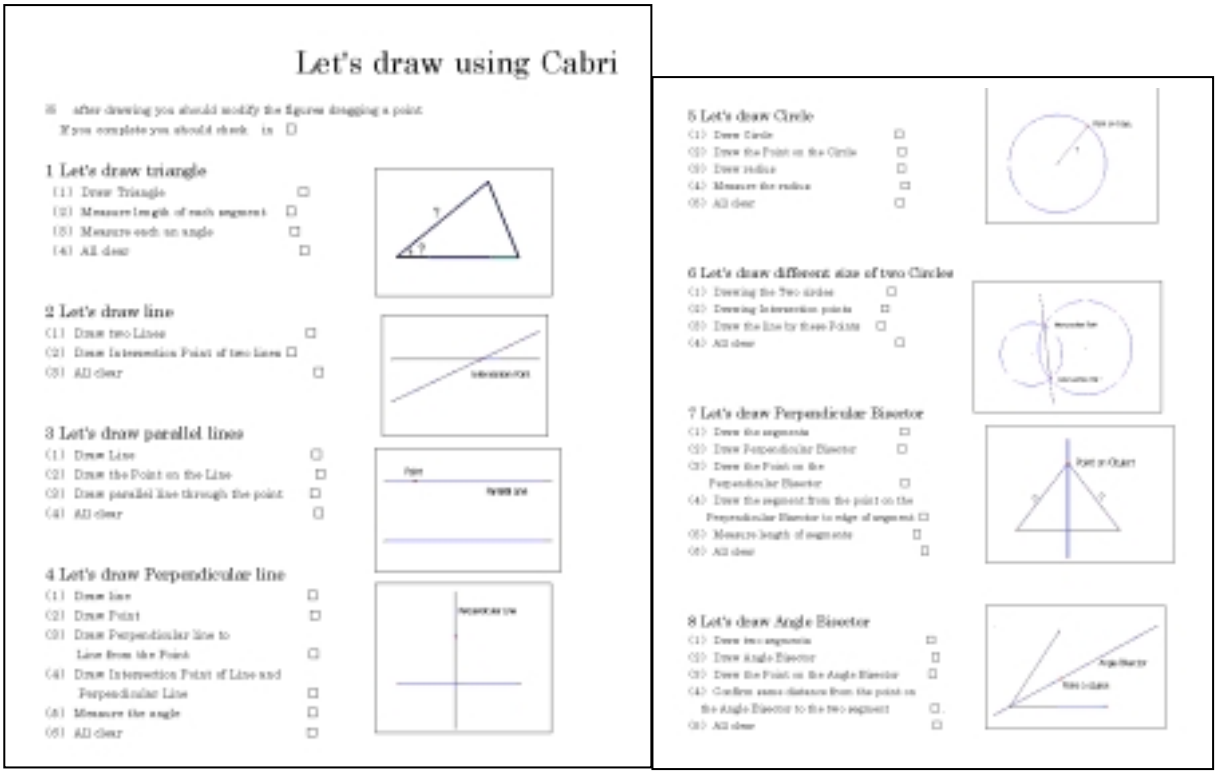
5. How to use Cabri in math class

(1) Atmosphere

I give the students time to use Cabri. They freely draw various figures using Cabri. They can easily draw many figures, from simple shapes to cartoon characters. Next they can move the figures or make geometric patterns.



(2) Practice Sheets



Let's draw using Cabri

※ after drawing you should modify the figures dragging a point.
If you complete you should check in ☐

1 Let's draw triangle
(1) Draw Triangle ☐
(2) Measure length of each segment ☐
(3) Measure each an angle ☐
(4) All clear ☐

2 Let's draw line
(1) Draw two Lines ☐
(2) Draw Intersection Point of two lines ☐
(3) All clear ☐

3 Let's draw parallel lines
(1) Draw Line ☐
(2) Draw the Point on the Line ☐
(3) Draw parallel line through the point ☐
(4) All clear ☐

4 Let's draw Perpendicular line
(1) Draw line ☐
(2) Draw Point ☐
(3) Draw Perpendicular line to Line from the Point ☐
(4) Draw Intersection Point of Line and Perpendicular Line ☐
(5) Measure the angle ☐
(6) All clear ☐

5 Let's draw Circle
(1) Draw Circle ☐
(2) Draw the Point on the Circle ☐
(3) Draw radius ☐
(4) Measure the radius ☐
(5) All clear ☐

6 Let's draw different size of two Circles
(1) Drawing the Two circles ☐
(2) Drawing Intersection points ☐
(3) Draw the line by those Points ☐
(4) All clear ☐

7 Let's draw Perpendicular Bisector
(1) Draw the segments ☐
(2) Draw Perpendicular Bisector ☐
(3) Draw the Point on the Perpendicular Bisector ☐
(4) Draw the segment from the point on the Perpendicular Bisector to edge of segment ☐
(5) Measure length of segments ☐
(6) All clear ☐

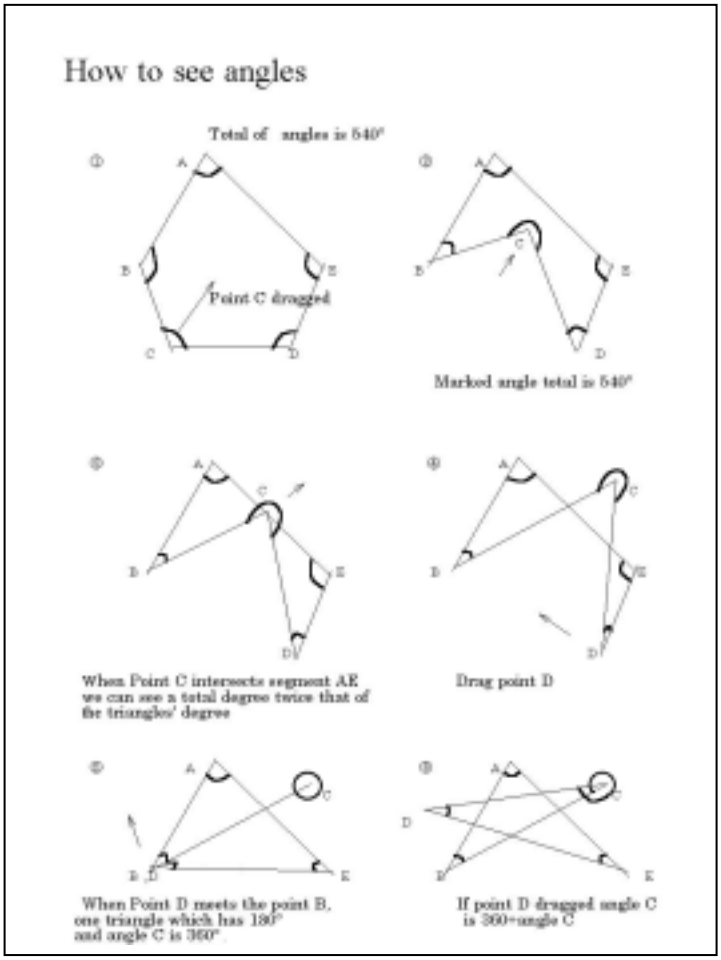
8 Let's draw Angle Bisector
(1) Draw two segments ☐
(2) Draw Angle Bisector ☐
(3) Draw the Point on the Angle Bisector ☐
(4) Confirm same distance from the point on the Angle Bisector to the two segment ☐
(5) All clear ☐

This sheet helps students become familiar with Cabri in only one or two class periods.
Students must draw figures to understand points of meaning, that is, points on the figure, or intersection points. This is challenging for the students.

(3) Developing Proofs

Explaining the total angle of the pentagrams is 180 degrees is the first formal proof that students

learn. It's from the 8th grade textbook. Students must find the total angle of the pentagrams.
It shows two ways to solve the problem. The first method uses the measured angles: the students make a model an paper which they can manipulate by cutting to bring the points together. The second uses the properties of the figure, which the students have already learned.
I always used Cabri to prepare this lesson. First I asked the students to make a pentagram. Then, I asked them to modify the pentagon by dragging a point. They enthusiastically worked on this problem. I asked the students to find the total angle of pentagram the same way as the textbook. Then they started to measure each angle and add them up.
Through this activity, they learned that any pentagram's total angle is the same. The students discovered why a pentagram's total angle is 540 degrees.

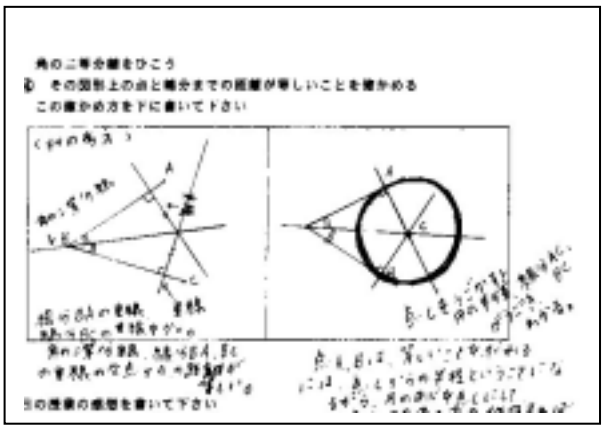


It shows using Cabri students find that pentagon's total angle is same as that of pentagram. As you can see on above last figure 360 degrees around angle C is hidden.

6. Discussion

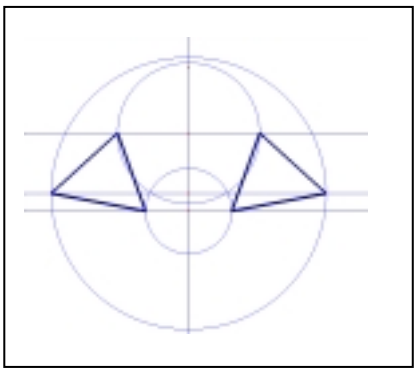
(1) Measure easily without thinking

It’s been said that if students measure the figures immediately, they won’t develop mathematical reasoning or logical thinking.
However, referring to the above pentagram example, if the students don’t measure the angles, they won’t notice certain properties about figures, and they won’t have a desire to complete the proof.
The students shouldn’t rely solely on measurements, though. They should confirm their answers, for example, by using circles or perpendicular bisectors to test the properties of various figures.
Following is a worksheet that my students completed. It appropriately illustrates that the distance from the points on the angle bisector are equal to two segments. She thought two ways to confirm the distance.

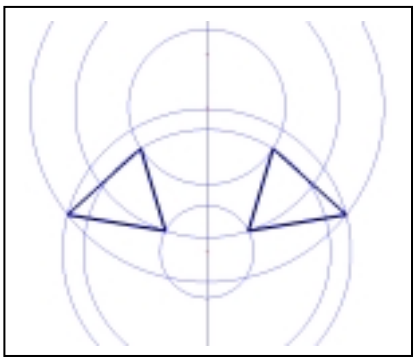


She thought two ways. Using a circle they can visually confirm their solution, and understand relationships between various figures.

(2) Use the function without thinking
Cabri occasionally makes students use convenient function without trouble. So it was said Cabri make them thinking less. Therefore I always taught students to construct the functions “midpoint,” “perpendicular bisector,” “reflection,” etc., by drawing circles.
Constructing these functions by themselves is an effective way to learn the concepts of the computer program. While they are constructing functions by circles and lines, they naturally feel the need to understand the logic and reasoning of the functions.
I presented the following problem to my students.
Make a reflection triangle ABC against the center line without using the Cabri function “reflection point.”
Many students constructed the reflection point on the following figure (1) according to definition, but some students drew a figure like figure (2), without using perpendicular lines.
Students who drew figure (2) understood why they could draw a reflection point. Drawing figures make them eager to do the proof.



figure(1)

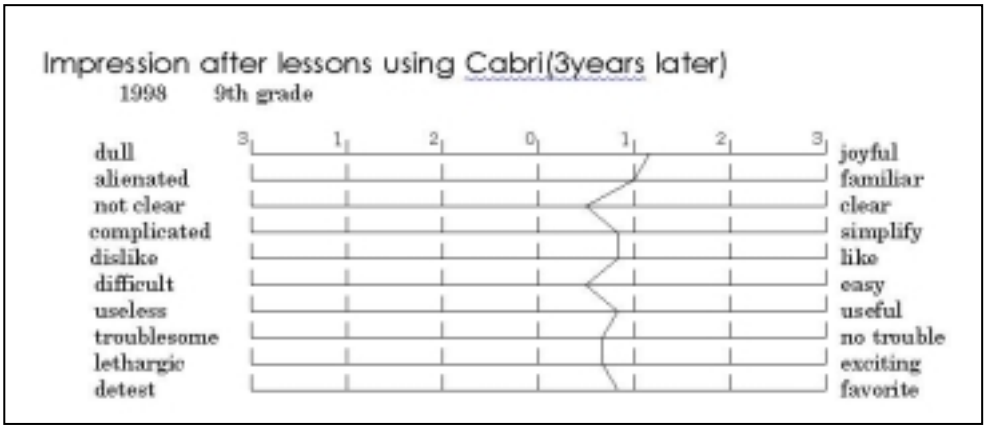


figure(2)

If they know the proof of congruence, they can explain why figure (2) is a completed reflection triangle.

7. Conclusion

There years after I started this study, I surveyed the students to find at their impressions of geometry again. Following is a graph representing the results of this survey.



According to above the graph and we mentioned thus far. I conclude following three points.

(1) Students can learn to draw figures, using Cabri, more easily than we previously thought.

(2) Drawing figures by themselves makes students notice new problems, which facilitates their mathematical reasoning.

(3) We prepared high quality lessons for drawing figures correctly and quickly after they observed dynamic figures.

Reference

[1]K.Harada,N.Nohda&E.Gallou-Dumiel. *France-Japan Cross-Cultural Research on Role of the Figures in Geometry*. Tsukuba Journal of Educational Study in Mathematics Vol.18,1999

[2]K.Kakihana & K.Simizu. *Activity of the students that we support with a computer.* Meijitosho(Japanese),1999