

Innovation of Mathematics Teaching with ICT

- The case of dynamic geometry
software: Geometric Constructor-

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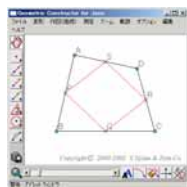
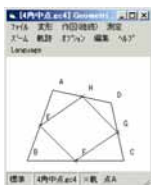
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1.Introduction

- *Geometric Constructor* (GC : in short) is one of the dynamic geometry software (DGS : in short) like *cabri*, *Geometer's Sketch Pad* etc., which is developed by the author. Since 1990, it has been used in many schools (mainly junior high schools) in Japan.

- And we had made lesson study with many teachers. In this paper, I would like to overview the outline of the innovation with GC, focusing the features of software and examples of lessons.



2.Features of Geometric Constructor

- 2.1.Dynamic geometry software used in Japan
- 2.2 Interactive theorem finding through variation of geometrical figure
- 2.3 Three styles of GC
- 2.4 Three modes of GC/Java
- 2.5 Web contents with GC
- 2.6 Instant web content making with GC

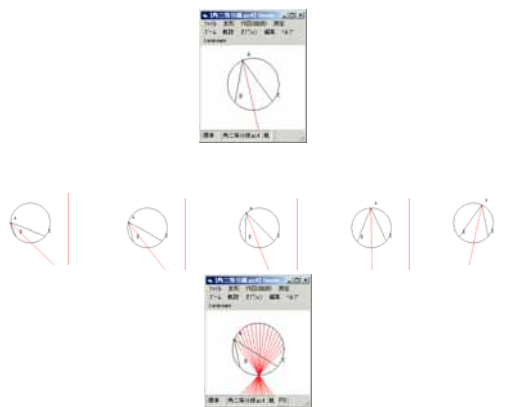
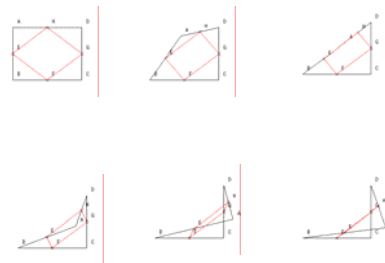
2.1.Dynamic geometry software used in Japan

- GC/DOS(1989 -)
- GC/Win(1997 -)
- GC/Java(2000 -, Iijima & Zeta)
-
- GC_BBS , PukiWiki with GC(2004,Iijima)
- GCL, dbook (2005, Zeta)



2.2 Interactive theorem finding through variation of geometrical figure

- Schumann (1991) mentioned about interactive theorem finding through variation of geometrical configuration with *cabri*. We can do it similarly with *GC*. We can use a mouse or keyboard to drag.



2.3 Three styles of *GC*

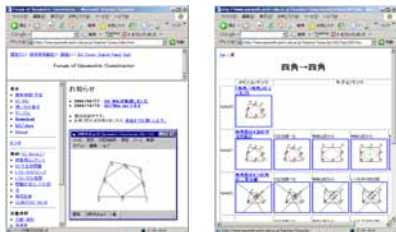
- Static web contents (for Presentation)
- Standalone software (for investigation)
- web application (for investigation)

2.4 Three modes of *GC/Java*

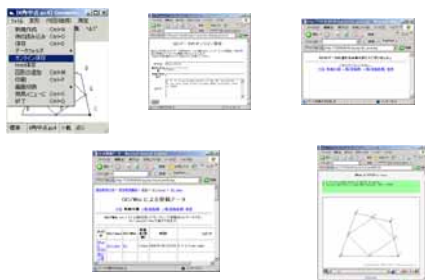
- **Viewer mode** : We can use only some functions ; drag, locus, zoom, etc.
- **Applet mode** : We can use some icon for construction.
- **Window mode** : *GC/Java* has the own window. We can use full menu of *GC/Java*



2.5 Web contents with GC



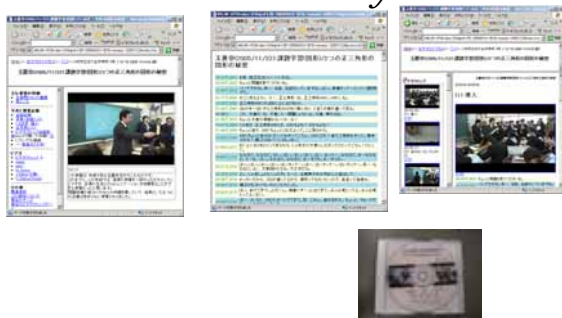
2.6 Instant web content making with GC



3. community of powerful users of GC

- One of the features of GC is the existence of the community or powerful users (mainly, teachers in junior high schools), which has made many discussions about software, web contents and lesson study.
- 1,000 e-mails for year
- This collaboration between researchers and teachers is very satisfactory for us. And it will be more important in the future. I think that we cannot realize it without ICT.
- One of the cores of discussion in this community is lesson study

4. lesson study and digital video library



5. internal standards to use GC in mathematics teaching

- 5.1 Use ordinary know-how for the whole-class discussion effectively.
- 5.2 Do not use technology excessively.
- 5.3 We use open approach in many case.
- 5.4 Elegant use of GC does not always make a good practice.
- 5.5 Not only objectively, but also affectively, subjectively.



Hershkowitz(2002) : the standards of CompuMath

- 1. Inquiry (observing, hypothesizing, generalizing, and checking) is a desirable mathematical activity.
- 2. Mathematical activity should be driven by the goals of understanding and convincing.
- 3. Proving is not only the central tool for providing evidence that a statement is true but should also support understanding why it is true.
- 4. Mathematical activity should take place in situations that are meaningful for the students.
- 5. Mathematical activity must stem from previous knowledge (including intuitive knowledge).
- 6. Mathematical activity should be largely reflective.
- 7. Mathematical language (notion systems) fosters the consolidation of mathematical knowledge; it should be introduced to students when they feel the need for it.
- 8. Technical manipulation is not a goal in itself but a means to do mathematics.

6. Some Lessons with GC

- 6.1 Angle of circumference: construction and group investigation with GC(2001)
- 6.2 Relation of Angles : presentation and group investigation with paper(2004)
- 6.3 Quadrilateral composed by four angle bisectors of a Quadrilateral: group investigation and whole class discussion (1992)

6.1 Angle of circumference: construction and group investigation with GC(2001)

In this lesson, we could use many but old computers. So teacher used *GC/Win* and students used *GC/DOS*. Teacher talked how to construct and measure the angle of circumference.

Problem : investigate about the angle ACB.



- 1 S1: (She is dragging point A) The size of this angle does not change. It is not interesting.
- 2 S2: Yes, it is not interesting.
- 3 S3: Teacher, this does not change. It is not interesting.
- 4 T1: What does not change?
- 5 S4: This angle.
- 6 T2: Why you feel not interesting?
- 7 S5: I hope the size of this angle to change.
- 8 S6: Why does not the size of this angle change?

- 1 T1: Drag the point (A).
- 2 S1: (He is dragging the point A)
- 3 T2: What do you find from this?
- 4 S2: The size of this angle does not change.
- 5 T3: (To the classroom) Do you find same thing?
- 6 T4: Other group found other thing. Talk about it, dragging it.
- 7 S4: If point A pass the segment BC, the size of this angle changes.
- 8 T5: Yes. Let's observe this on your computer, and find what happens.



- 1 S1: This angle is 54 degrees.
- 2 S2: Yes, it is just.
- 3 S3: Very comprehensible! (The sum of two angles is 180 degrees.)



6.2 Relation of Angles : presentation and group investigation with paper(2004)

- In this lesson, teacher use a computer with projector. Teacher showed the relation of the angles which was learned at previous lesson. And he dragged the vertex and show some other relations.

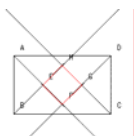


And he asked to make new problems by the change of some condition of original figure.



6.3 Quadrilateral composed by four angle bisectors of a Quadrilateral: group investigation and whole class discussion (1992)

- 1st : computer room
- 2nd: ordinary classroom

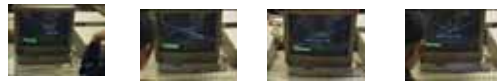


- Teacher show how to investigate and how to use the software using previous example.



ABCD	EFGH	
Square	Square	
Rectangle	Rhombus	
Rhombus	Rectangle	
Parallelogram	Parallelogram	
Trapezoid	Parallelogram	
Kite	Rectangle	
Quadrilateral	Parallelogram	
Wedge	Parallelogram	

Table 1: relation of quadrilaterals (1)



ABCD	EFGH	EFGH (supposition)	Sketch
Square	Point		
Rectangle	Square		
Rhombus	Point		
Parallelogram	Rectangle		

Rhombus	Point		
Parallelogram	Rectangle		
Trapezoid	$\angle BEF = \angle DGF = 90^\circ$		
Kite	Point		
Quadrilateral	Quadrilateral		
Wedge	Two triangles		

Table 2: relation of quadrilaterals (2)



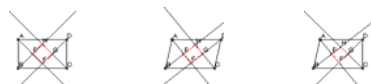
- 1 T1: What is a difference between your supposition and observation.
- 2 S1: Parallelogram is ...
- 3 T2: Parallelogram is ?
- 4 S2: Parallelogram is missed. (Students laughed.)

This student pointed out that parallelogram was supposed in some column but he could not observe it. Other student pointed out rhombus and trapezoid too. They got problems.

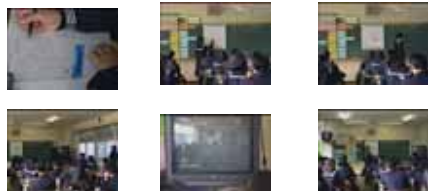
- Is this table valid?
- Can we make EFGH parallelogram, rhombus, trapezoid?
- If we can not, why?

2nd Lesson

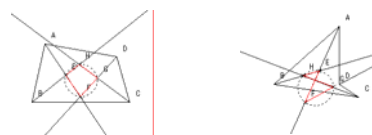
Proofs about three special cases



Proof about general case



They found EFGH was a cyclic quadrilateral in any case, therefore EFGH can not be parallelogram, rhombus.



7. Discussion

- Mathematical activity can be supported and fostered with ICT
- Know-how of the whole-class discussion is appropriate with ICT
- How to make the *de facto* standards for mathematics teaching with ICT in Japan
- Lesson study is important to collaborate with teachers in Japan

7.1 Mathematical activity can be supported and fostered with ICT

- With computer, we can investigate mathematical problems deeper and wider. We have experienced this since 1990.
- But, how many teachers have experienced and enjoyed deeper and wider investigations with computer? Not so many, I suppose.
- This is a serious problem for the expansion of the use of ICT in mathematics teaching in Japan.

7.2 Know-how of the whole-class discussion is appropriate with ICT

- According to the e-Japan strategy, we will use a computer with a projector in a ordinary room.
- But, one way presentation is more tedious for students than traditional chalk-and-talk style. To be more attractive, we should use the presentation interactively. Is it difficult? No, I think. Because, many teachers have the know-how about the whole-class discussion in Japan.
- I hope it make the breakthrough of the Japanese style lesson with ICT.

7.3 How to make the *de facto* standards for mathematics teaching with ICT in Japan

- In fact, many teachers do not use ICT in mathematics teaching in Japan. I think that one of the reasons is the lack of the standards for mathematics teaching with ICT in Japan. It is not good for us, of course. But, what can we do in this condition?
- I think the answer is to make *de facto* standards, which may be possible with ICT as an infrastructure for teachers.
- Of course, it is not so easy. But we can provide softwares and contents from our servers. We can make a community to discuss and collaborate.

7.4 Lesson study is important to collaborate with teachers in Japan

- Many teachers want to make a good practice. Using ICT is not a goal in itself. It is a means to do a good practice. To collaborate with teachers, lesson study is important.
- For example, we had a lesson study at Hikarigaoka junior high school at Komaki on 22 November, where we had a comparison between lessons with *GC* and without *GC*. Over 100 persons came to observe and discuss the lessons. They discussed eagerly. We made resources (transcriptions, video-clips, etc.) for the discussion, and had a meeting on 23 December at Komaki. Over 60 persons attended and discussed.

8. *Conclusion*

- The history of *GC* is the history of collaboration with teachers. Designing and implementation of the software is my task. But to device user-friendly interface, the monitoring by teachers is necessary. I have experienced my own mathematical investigations with *GC*, and proposed problems to teachers.

- They have accepted them and revised them suitable to their students. The core of collaboration has been lesson study. To make a good practice, we have had many discussions before and after the lesson. That produced many mathematical problems, know-how, lesson plans and hints for improvement of software and contents.

- In this process, ICT has been useful for us. We can provide software and contents with our server in the Internet, and we can discuss almost everyday with mailing list. Now, we are trying to make and use the digital video library of lessons.
- It is not easy to make a good lesson study, but it is challenging for us.