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## **GC/HTML5 : DYNAMIC GEOMETRY SOFTWARE WHICH CAN BE USED WITH IPAD AND PC**

### **- FEATURE OF SOFTWARE AND SOME LESSONS WITH IT -**

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*Geometric Constructor (GC/DOS, GC/Win, GC/Java) is one of the dynamic geometry software used in Japan since 1989. GC/html5 is developed with html5 and JavaScript in 2011, which can be used with iPad and PC. Students used it interactively with no stress, which meant we can use html5 and JavaScript to develop interactive geometrical software for iPad and PC. The basic feature of our lesson and two example are described.*  
*dynamic geometry software, html5, iPad, GC*

## **INTRODUCTION**

In Japan, dynamic geometry software has used in many schools, since 1990. One of the dynamic geometry software used in Japan is GC (*Geometric Constructor*), which is developed by the author. GC/html5 is the newest version of GC which is developed since 2010. In this paper, I describe the feature of GC/html5 and some lessons using GC/html5 with iPad in junior high schools.

### **1. OUTLINE OF THE SOFTWARE GC/HTML5**

#### **1.1 Background**

GC/html5 is one of GC software series which is developed by the auther (GC is a simplified name of *Geometric Constructor*). GC/DOS was developed since 1989, GC/Win was developed since 1997, GC/Java was developed since 2000. They are one of the dynamic geometry software, which is used in many schools in Japan. Using them, we can construct geometrical objects(points, segments, half lines, lines and circles), measure them, drag some points of them, make traces of geometrical objects. Of course, GC/Java can be used as the viewer of dynamic geometry in the web contents. But we can use GC/Java as same as GC/Win. We can construct geometrical figure and save it to the web server. Providing some plug-in, we can use GC/Java in PukiWiki, which is one of the typical Wiki system, to make many web contents.



Figure 1. Traces of inscribed centers of triangle constructed with GC/DOS (1989)

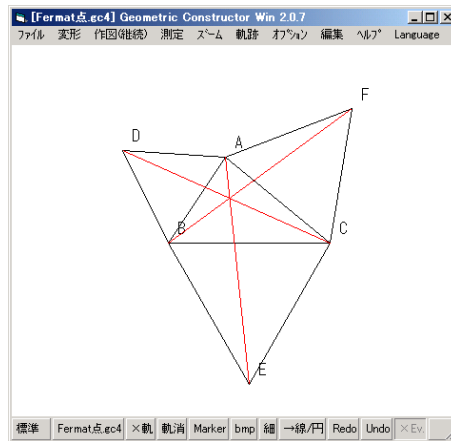


Figure 2. Fermat point constructed with GC/Win (1997)

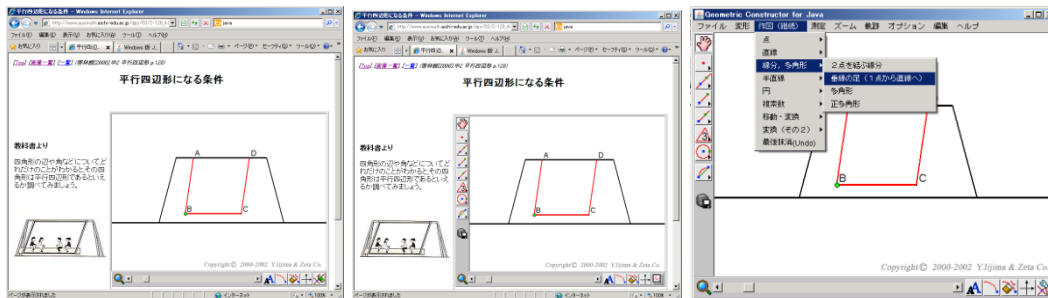


Figure 3. Three modes of GC/Java (2000)



Figure 4. GCWiki (2003)

The emergence of iPad made a big impact for us. But, we cannot use neither GC/Win nor GC/Java with iPad. New type software of GC should be developed for the both use with iPad and PC. To satisfy this condition, I challenged to the development of GC

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with html5 and JavaScript; it is named as GC/html5. The roadmap of this development is following;

1. Development of some tiny web-content with figure, points of which can be dragged with mouse/touch according to the standard of html5.
2. Development of objects including geometrical objects (point, line, circle etc.) with JavaScript, which is needed to GC/html5.
3. Using above objects, development of some web-content with figure, points of which can be dragged with mouse/touch.
4. Development of the viewer version of GC/html5; to read the GC/Win file and display it to be dragged with mouse/touch.
5. Development of the standard version of GC/html5; following function is added; construction, measurement, trace and file I/O (online and offline).

And at each stage, we have used them in lesson to check and revise. In 2010, the viewer version was finished and the standard version was finished in 2011. With iPad students used GC/html5 interactively with no stress about the smoothness of the motion of figure, which meant we can use html5 and JavaScript to develop some interactive geometry software for iPad and PC, nevertheless JavaScript is not so fast language as native C/C++ or Java.

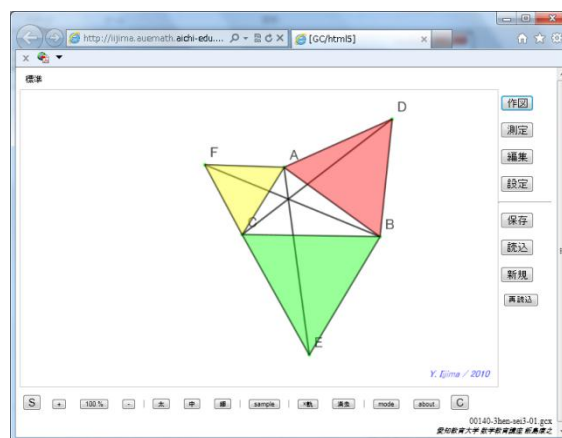


Figure 5. Fermat point constructed with GC/html5 (2011) using IE9

## 1.2 main features of GC/html5

### (1) drag by mouse or touch(es)

We can drag the figure by mouse (PC) or touch (iPad). In the case of touch, we can drag some points simultaneously (maximum: 5 points) using some fingers. Or some students drag points simultaneously. This feature is inherent in iPad and it is remarkable feature for the mathematical activities with some problem (see 2.3) and it is also remarkable in group investigations.

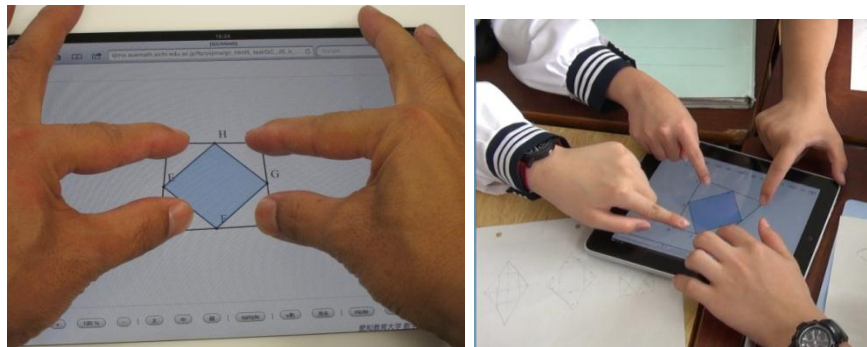


Figure 6. Drag by touches

Point is projected to the nearest geometrical object (line, circle) by dragging with pressing “S” button (or pressing Shift key in the case of keyboard). In the case of following figure, it is easy to project the point P to the circle and find the relation of two angles.

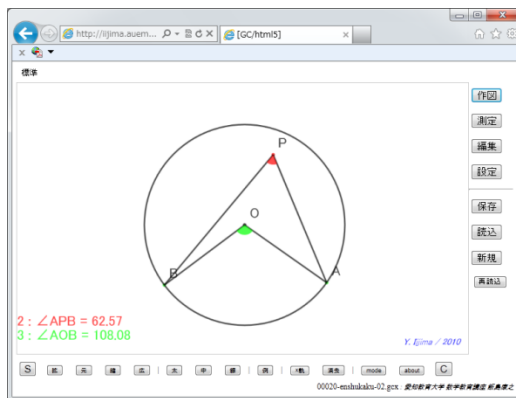


Figure 7: P is not on the circle

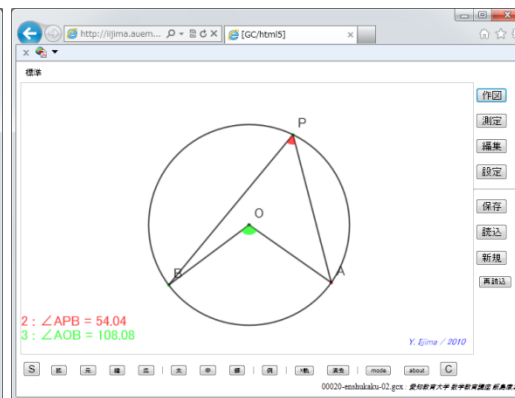


Figure 8: P is placed on the circle

And point is moved to the nearest lattice point by dragging with pressing “C” button (or pressing Ctrl key in the case of keyboard).



Figure 9: C is free

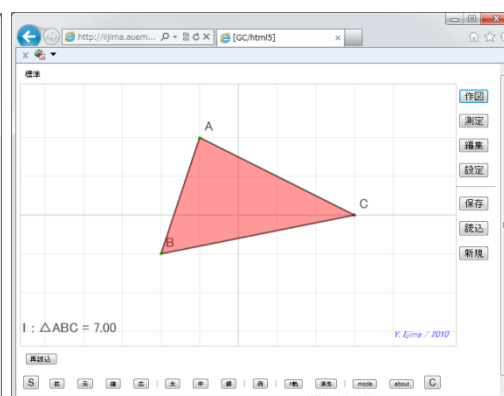


Figure 10: C is on a lattice

## (2) construction and measurement

The construction of a geometrical figure with GC is started by making some independent points. And in each construction we select the kind of new geometrical

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object (point, line, segment, half-line, circle etc.) and select basic construction to make that object and some geometrical objects (points or segments etc.), which is used for the basic construction.

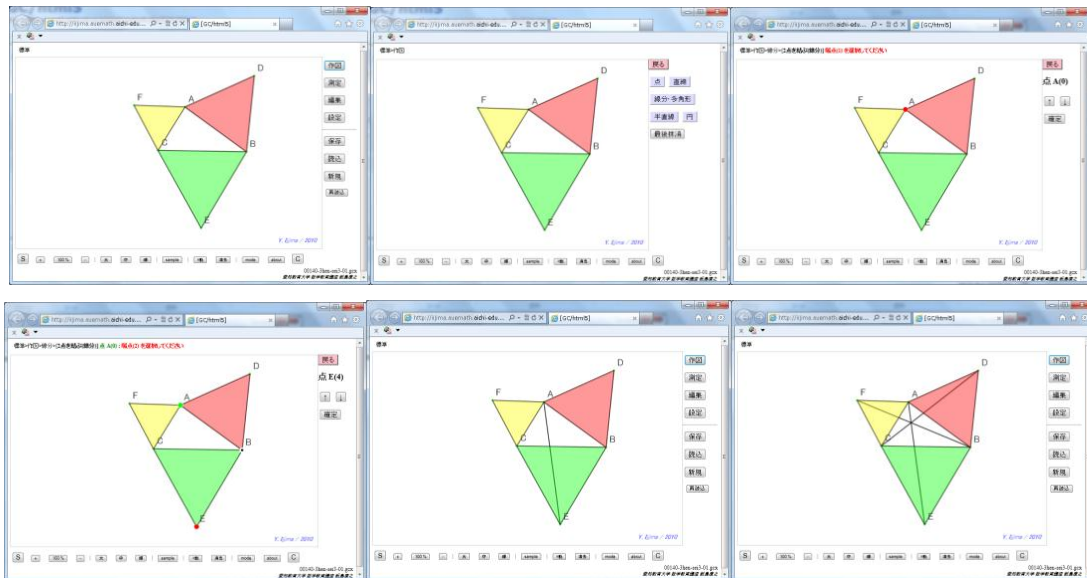


Figure 11. Construction of Fermat point with GC/html5

We can make measurement in similar to constructions.

### (3) trace of geometrical objects

By editing the attribution of geometrical objects and set the switch of tracing ON, we can trace of the point or line etc.

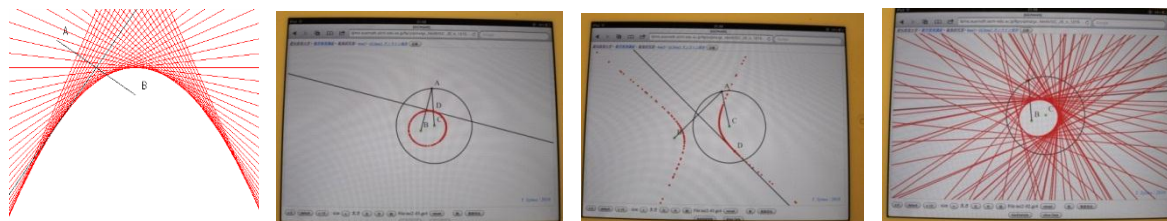
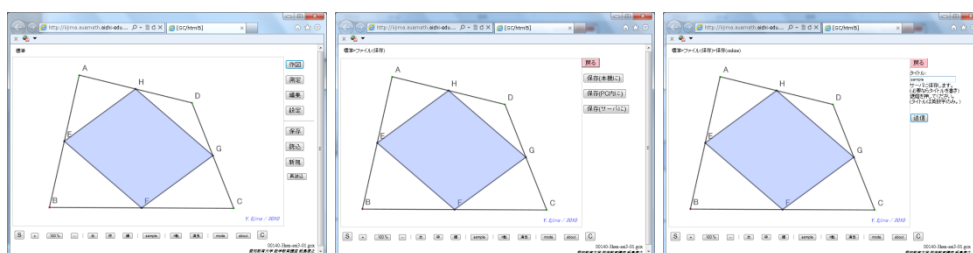


Figure 12. Traces of point and line which show quadratic curves

### (4) saving of the figure file

Usually, we save the figure data to the server in the Internet using on-line saving and we get list of urls of figure to show with GC/html5 as follows.





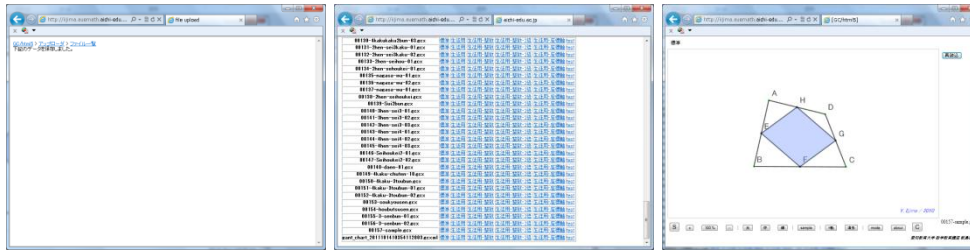


Figure 13. On-line saving and the list of saved figures

We can save figure data locally to iPad or PC (web storage, 10 files maximum) and read it as follows.

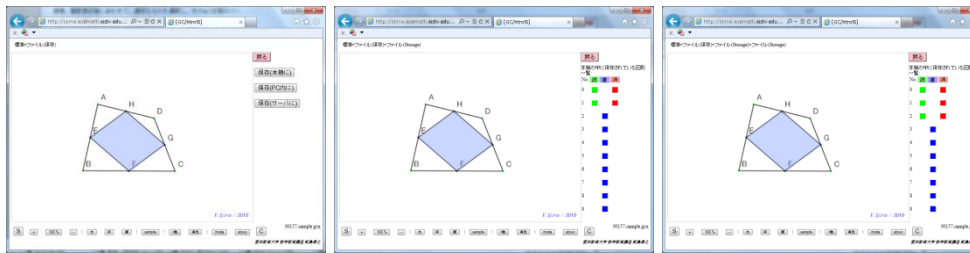


Figure 14. Local saving to the web storage

## 2. Lessons using GC/html5 and iPad

### 2.1 basic feature of our lesson using GC/html5

Teachers use some technology such as iPad, digital board and OHC. And they use blackboard and paper effectively, also. It is same case with students. They use not only iPad, but also worksheets and notebooks effectively (See 2.3). It is important to use iPad in usual classroom and usual teaching and learning style.

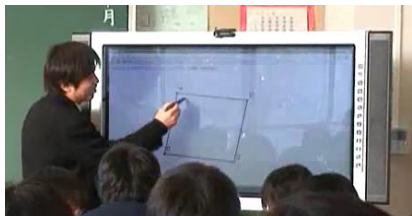


Figure 15. Digital board



Figure 16. OHC



Figure 17. Blackboard

Four students use one iPad which is placed at the center of their desks connected as follows. In this style, they can also use notebooks, textbooks and work-sheets on their desk. They use iPad for their investigation interactively with their discussion and they use OHP sheet to copy the figure on iPad. And they use notebook to record their observations, idea and proof.



Figure 18. Students' activity with iPad and TP sheets.

## 2.2 example 1: the place of A to make ABCD rectangle (5 minutes use of GC/html5)

By iPad, we can use GC/html5 easily than the case of PC and GC/Win, in which, it is almost impossible to have an effective investigation in a short time (five minutes). But by iPad, we have done effective lessons in five minutes use of GC/html5. “only five minutes use” is important to use GC/html5 in usual lesson. Following is an example of “only five minutes use”.

**Problem :** There is a parallelogram ABCD on iPad. According to the drag of the point A, point C will move (Figure 19). Drag point A to make ABCD rectangle, and record the place of A. Investigate the place of A to make ABCD rectangle.

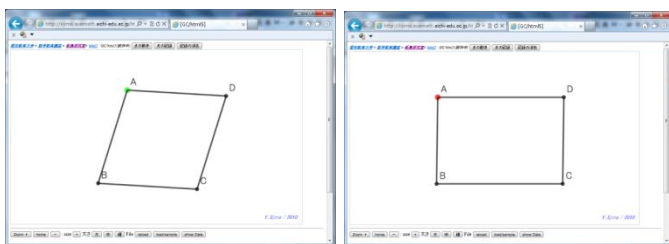


Figure 19. Parallelogram and rectangle

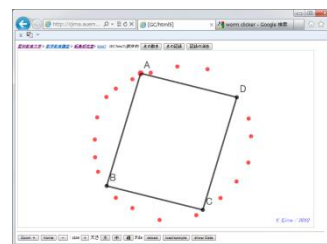


Figure 20. Example of a record of A

Teacher showed the problem with a digital board (Figure 15) and gave each group iPad and TP sheet. Students placed TP sheet on the iPad and they drag point A to make ABCD rectangle and mark to the TP sheet the place of A (Figure 18). Teacher gathered and pile TP sheets and showed it with OHC (Figure 16). By the observation of the result, they thought that result showed a circle, and thought about the proof with their group. Then a student explained her proof on the blackboard (Figure 17).

## 2.3 example 2: What is the condition of ABCD to make EFGH square

Teacher showed the figure with projector and said “E,F,G,H are the midpoints of segments AB, BC, CD, DA(Figure 21). Move points A,B,C,D to make EFGH square”. Students touched points as Figure 22.

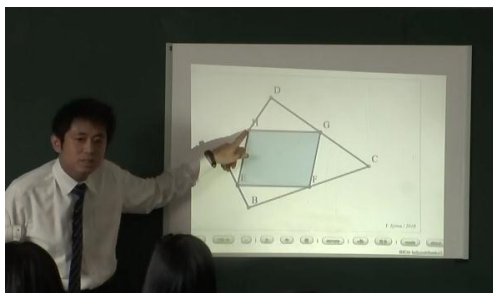


Figure 21. Problem posing with OHC      Figure 22. Student made ABCD square

Teacher said “If ABCD is square then EFGH is square. I wonder that if EFGH is square then ABCD is square or not. Investigate about it with iPad.” Students found the case of ABCD was not square but EFGH was square. Then teacher asked to find the condition of ABCD to make EFGH square.

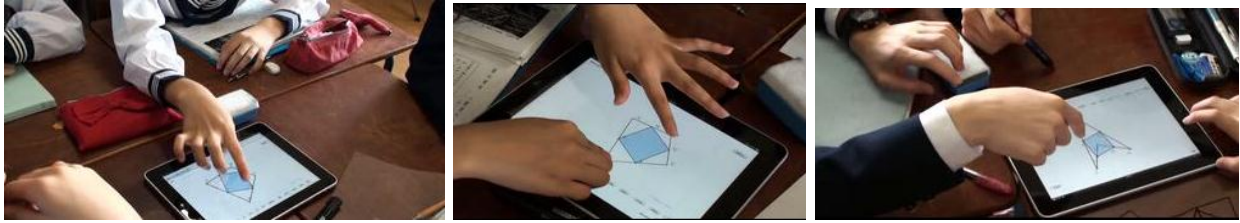


Figure 23. ABCD is not square but EFHG is square

In each group, students found several cases (Figure 23). And some students found that if they move A and C in same direction then EFGH is still square in same scale, and if they move A and B in some rule then EFGH is still square in different scale (Figure 24). Students discussed each other with free-hand drawing on TP sheet or notebook (Figure 25).

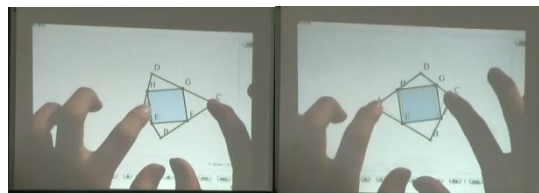


Figure 24. Moving points A and C in same direction

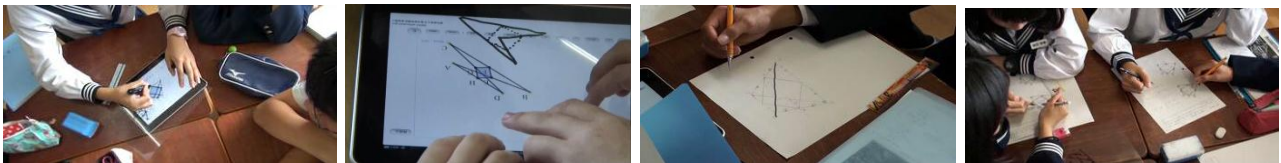


Figure 25. Drawing and discussion with TP sheet on iPad and notebook

Finally, teacher asked to two students to explain the proof at the blackboard.

### 3. Conclusion

GC/html5 was developed based on GC/Win using html5 and JavaScript for the use with iPad and PC. At the each step of roadmap, we used it in the lesson to check and revise. Students used it interactively with no stress, which meant we can use html5 and JavaScript to develop interactive geometrical software for iPad and PC. Example 1 illustrates 5 minutes use, which is suitable for the usual lesson. Example 2 illustrates mathematical activities with GC/html5 with a plenty of time.

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