Mathematics Classroom Innovation with Technology Japanese Movement

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Abstract
Current Japanese technological innovation in mathematics classroom is illustrated by the following categories of classroom technologies: Computer Supported Collaborative Learning, Free Software, Commercial Software and Free web-based material.

Introduction

Many technologies for classroom use have been developed in East and Southeast Asia. But how do Japanese teachers use such technologies in their mathematics classroom? We try to answer this question by demonstrating innovative classroom technologies in Japan. We have classified them into four categories of technologies using the nature of software or learning environment. The first one is technology as a learning environment, *Study Note*. This computer supported collaborative learning system is one of the most major systems generally used in elementary and middle school in Japan. The second refers to free software packages developed by Japanese math-educators. We will present GRAPES and Geometric Constructor which are most popular in Japan mainly at secondary level. The third is a commercial software package of teaching materials which can be used in daily mathematics classrooms. Many software and teaching materials in this category are developed by software companies or textbook publishers and also by math-educators. The fourth refers to websites containing teaching and learning materials which are developed for teachers and students. The National Information Center for Educational Resources (NICER) stocks most of the educational resources and can be seen on web.

Computer Supported Collaborative Learning with Teachers' Community

Tsukuba City is one of the most advanced municipalities in Japan in terms of ICT education. An ICT education project that uses groupware and the Internet was started in 1995. Currently, all the 53 elementary and middle schools in the city are interconnected by optical fiber cables and a teleconference system and information sharing systems for promoting ICT education research. The schools are equipped with a groupware *Study Note* developed by Sharp System Products, Co., Ltd. and university researchers (Yoden & Yamanoi, 2004; Yoden et al., 2003). *Study Note* and other systems enable students in Tsukuba to engage in question and answer sessions or exchange information with any students or teachers in the city.

Almost 40 projects are ongoing with participation of several schools. All school subjects are included in the projects: mathematics (figure1), sciences, social studies, languages (Japanese and English), music, physical education, etc. Over 15,000 e-mails per year are exchanged in these projects. Students make the use of ICT in various ways; for example, to receive advice from researchers who work in the city's research institutes and to hold discussions with other schools' students.

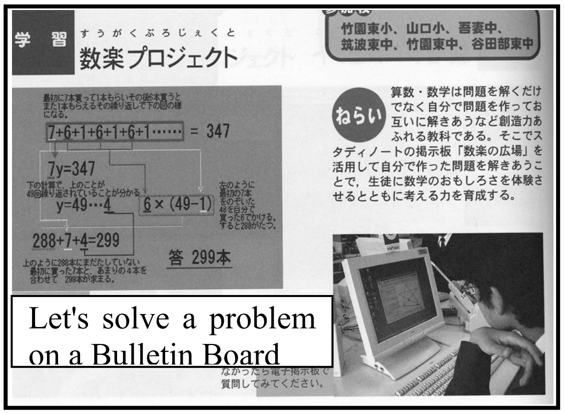


Figure 1. Page of a Project of Mathematics

Figure 2. Using a palm computer

Currently, *Study Note* is installed in about 8000 schools in the world. The number of members on mailing list for Study Note is 450 teachers and researchers. In addition, all students attend the Tsukuba's annual ICT education meeting. For its efforts in promoting ICT education, Tsukuba City was awarded a national prize by the Prime Minister in 2003 at Internet Use Education Contest held by the Ministry of Education, Science, and Culture Japan (MEXT). This year, a research group implemented *Study Note* on Palm computer with digital camera. Students in Tsukuba have been using it in their classes. Using a Palm computer, students can observe objects, take pictures and comments on their observations on it, and then immediately send their written observation (figure 2).

Activities with *Study Note*

The groupware *Study Note* was developed from ideas of school teachers of various subjects. It has four functions: Note book, E-mail, Bulletin Board and Data Base (Fig. 3). Students start off by writing a digital note book.

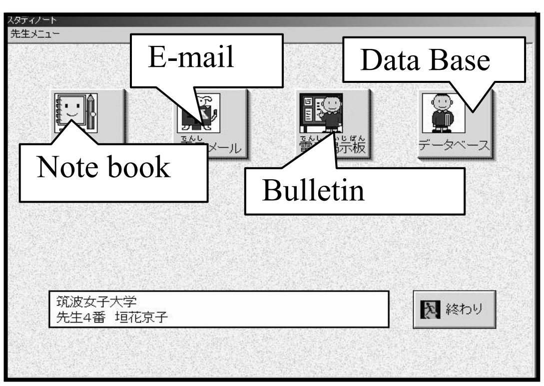


Figure 3. Top of Study Note

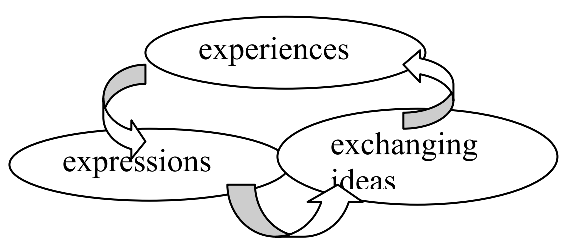
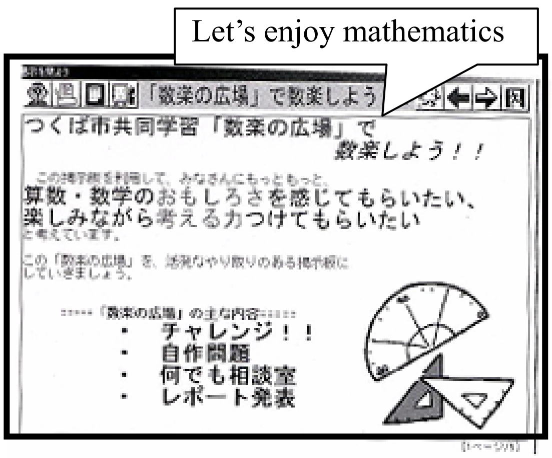
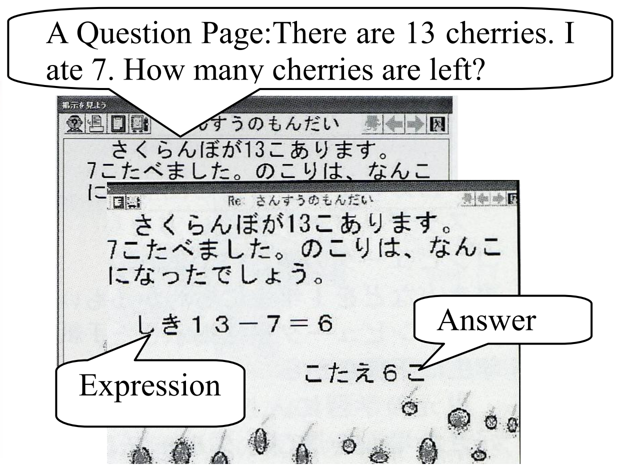


Figure 4. Concept of activities on "Study Note"

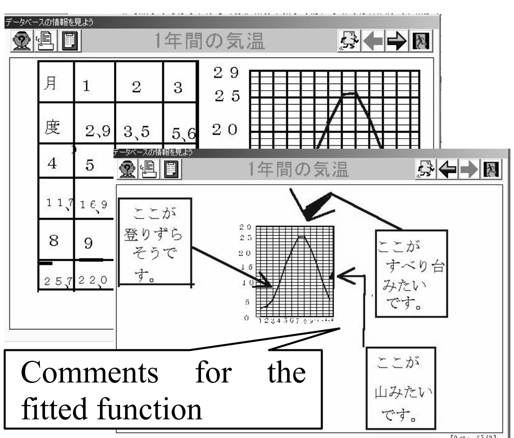
Using *Study Note*, students can use also paper and pencil: writing sentences, drawing pictures and attaching pictures/figures. They can attach sounds/movies also. They can describe the chain of their ideas and report on their activities. They are able to send these notes to others and to obtain advices from others by using E-mail or the Bulletin Board. They also exchange opinions on their Note Book and revise their ideas and knowledge through the Data Base. They can easily edit or restructure their written texts. They use the Data Base for portfolios and for storing their projects. They can develop new ideas and reconstruct their knowledge through three types of activities (figure 4): hands-on experience, written description of the experience and exchange of ideas about the experience.





· Figure 5. Top page of Plaza of Mathematics

Figure 6. Problem Posing and solving



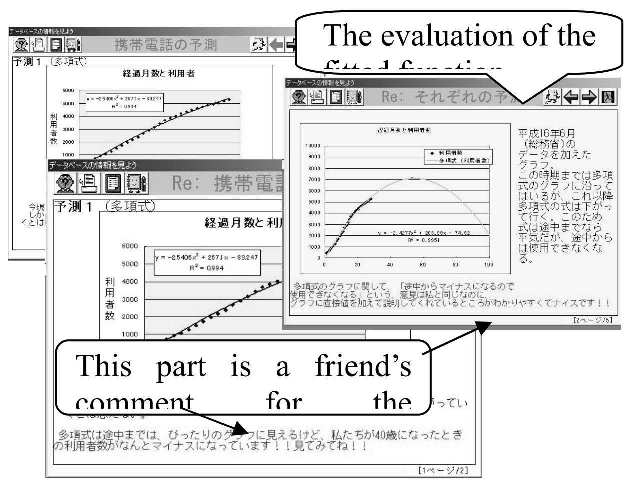


Figure 7. Fitting data by a junior high school student

Figure 8. Fitting data by college students

Example 1. Plaza of Mathematics: Let's pose a problem
An example of a collaborative mathematics learning activity among schools in Tsukuba is the Plaza of Mathematics (figure 5). In this project, students tackle mathematical problems posed by teachers, other adults or students (figure 6). They can also ask questions or present reports. Through this activity, students are expected to enjoy creating their own question in mathematics.

Example 2: Reports of fitting functions
Students learn how to fit functions for data on a spreadsheet and then write up a report about the activity on Study Note (figure 7). College students also use Study Note in statistics course to fit data by using many kinds of functions and to estimate future data and to evaluate which function is most appropriate. They comment on their estimations among themselves through this system (figure 8).

Free Software Environment

The educational technology for mathematics teaching and learning has been advanced dramatically during the past decades, such as graphing calculators (Casio, TI, etc.), dynamic geometry software (Cabri-géomètre, Geometer's Sketchpad, Cinderella, etc.), Computer Algebra System (CAS: Mathematica, Derive, Aplusix, etc.). We present here GRAPES (GRAph Presentation & Experiment System) and GC (Geometric Constructor) both developed in Japan, and their educational potential.

User Friendly Graphing Free Software: GRAPES
GRAPES is a graphing software that allows graphical representations of most of the functions and relations which appear at the secondary and undergraduate levels. It has almost all the functionalities of a graphing calculator except numerical and algebraic calculations. GRAPES is not a CAS like Mathematica and Drive in the sense that it has been developed just for the educational purpose of visualizing functions and relations especially for secondary mathematics education.

The first main function of GRAPES is, like other graphing software, immediate drawing of graphs to a given algebraic expression. This function has the potential to dramatically change the teaching and learning of functions (see Romberg et al (eds.), 1993). Traditionally, only few specific types of functions having specific symbolic expressions such as linear function, quadratic function, etc. may be drawn on paper. Graphing software enables the immediate drawing of graphs and allows students to explore several graphs of functions and situate the specific traditional types in a spectrum of functions including those of complicated algebraic expressions. Moreover, whereas the graph was often an end point of mathematical problems in the traditional way, the approach from the graphical representation is also possible, such as finding the algebraic expression to a given graph or given phenomena.

The second main function of GRAPES refers to parameter and locus. Using parameters and locus, it's easy to visualize families of curves of functions and relations. The roles of parameters on the expression of function are visible through exploring the graphical and analytical nature of certain families (see Figure 9). Parametric curves can be also easily drawn.

Graphing calculators are actually not common in Japanese classrooms. GRAPES is one of the most used software in ordinary mathematics classrooms in Japan. There are two main reasons why. First is due to its usability, the highly friendly interface makes it easy to integrate to the time limited lesson. The second reason is due to the fact it is *Freeware*. GRAPES is developed by a high school teacher Katsuhisa TOMODA (Ikeda Senior High School Attached to Osaka Kyoiku University). He is not developing it for the commercial purpose, but just for himself and his colleagues in order to enrich and make their mathematics class more active. This kind of freeware for educational use is often developed in Japan. We can also find a freeware of the dynamic geometry software for the geometry learning, Geometric Constructor. GRAPES is now translated in English and in Spanish and downloadable from the website: http://www.criced.tsukuba.ac.jp/grapes/

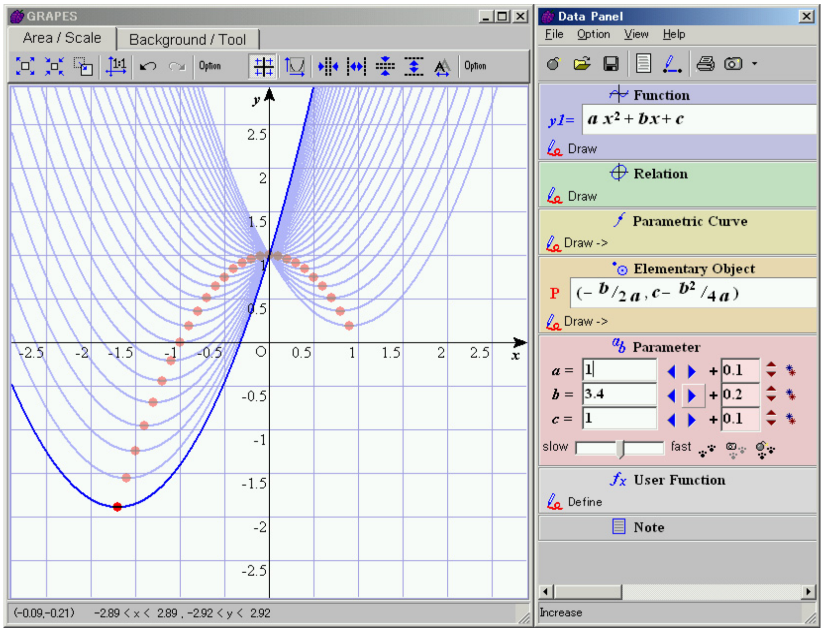


Figure 9. Interface of GRAPES
http://www.criced.tsukuba.ac.jp/grapes/
http://www.criced.tsukuba.ac.jp/grapes/es/

Dynamic Geometry Free Software: GC

GC (Geometric Constructor), Dynamic Geometry Free Software, was developed by a Japanese researcher Iijima Y. (1995). GC is a dynamic geometry software (DGS) like other famous software (ex. Cabri-geometry, Geometer's Sketchpad). Many Japanese mathematics teachers, mainly middle school, used GC in their classes and have a community in which they can discuss on the students' responses and also how to use GC more effectively. Iijima has also developed a website in which interesting problems using GC for students are presented. Some of those contents were developed through discussion with users. Because the interface of GC and website are in Japanese, it is not available for teachers and researchers in foreign countries. Japanese researchers have began to translate the website and its contents into English. They are also planning to translate this website into Spanish. It is a way for expanding the availability to more people.

Figure 10 is an example of GC problems website which has already been translated. In this website, we use JAVA applet to be able to manipulate the figure directly with mouse. There is no neede to install GC software in each computer. Teachers don't have to distribute files which are used in their lessons. Most of the people who access this website can manipulate this figure and explore, for example this problem. In this problem, students move points A, B, C and D and try to find geometrical properties (ex. Quadrangle PQRS is always parallelogram). An additional line, circle, polygon and so on can be also drawn with tools in this window. It can help students to explore more deeply and verify their conjecture. The website (http://www.criced.tsukuba.ac.jp/gc/GCWorld.htm) has 19 themes and there are about 20 problems in each theme. The example shown above is a problem from one of them. Most of problems are focused on secondary school level.

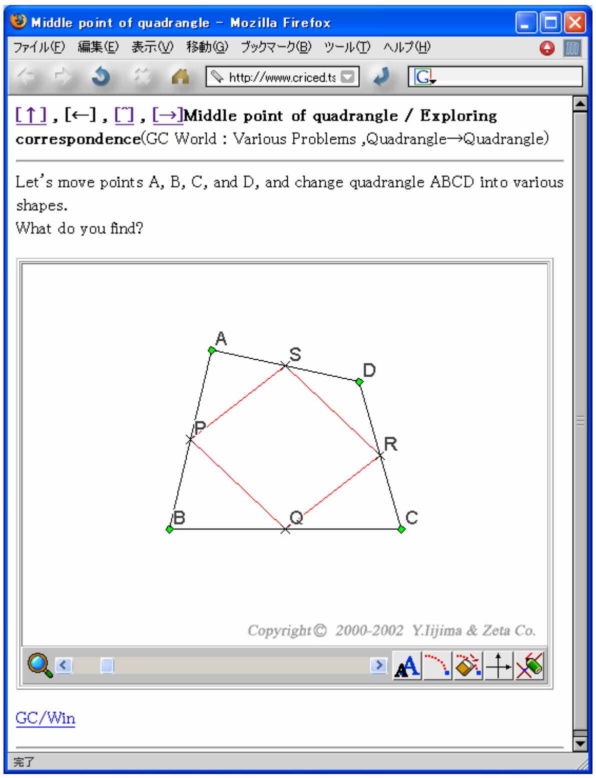


Figure 10: An example of GC problems
http://www.criced.tsukuba.ac.jp/gc/GCWorld.htm

Figure 11: The top page of on Math on Projector consists of a photograph expressing a familiar mathematical phenomenon.
http://www.culture-pro.co.jp/mop1/menu.html
http://www.culture-pro.co.jp/mop2/menu.html
http://www.culture-pro.co.jp/mop3/menu.html

Use of Projector and E-blackboard

In Japan, all schools are expected to be equipped with Internet and Projectors by the Ministry of Education. During the past 5 years, many new innovative tools for classroom use have been developed commercially for use by teachers. ‘Math on Projector’, ‘e-textbook’ and ‘d-book’ are current famous products by companies.

Math on Projector

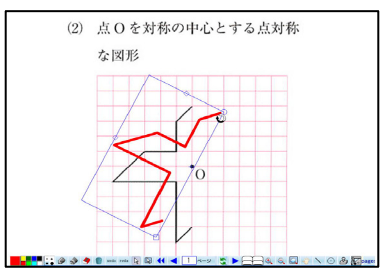
“The Math on Projector” is a collection of mathematics teaching materials with computer for 7th to 9th grade (1st to 3rd grade in junior high school in Japan). It contains materials which can be used in ordinary lessons and also for advanced classes. The data created by Cabri Geometry II can be perused and manipulated through Cabri Java. The Math on Projector has 26-29 materials for each grade. Each of them consist of a sequence of "Let’s explore", "Let’s verify", "Let’s use", and “Let’s develop", and contain 4-6 data of geometrical construction (more than 100 data for each grade). Work sheets, examples of answers, etc. are also prepared for each content. All contents are developed by Kawakami, K. and Uehara and edited by Isoda, M.. Math on Projector was awarded a national prize by Minister of Education in 2005.

E-textbook

The “e-textbook”, created by the textbook publishers, is a teaching material for lessons using projector. By the “textbook viewer” of e-textbook, a page of textbook displayed on a screen can be zoomed in and we can write or draw anything there. Moreover, the items created by Flash put on the text page, can be manipulated on the screen. The figures drawn with the “textbook viewer” can be translated, rotated, reflected, and dilated. With the “electronic information board”, even the teachers and students who are not used to a computer can also write in or manipulate objects easily.

"dbook" as a tool to develop e-textbook

In order to suppress the production costs of the basic tool of a textbook company, "dbook" was developed to improve the quantity and quality of digital contents, and to enable many textbook publishers to gain access to the market regardless of capital power. After scanning the page of a textbook, "dbook" allows to stick Flash items teaching materials on them. In order to create these items, we have developed "GCL (Geometric Construction Language)", a description language for the Flash geometrical IT contents. GCL is based on XML. It is superior in readability and has open specification which is rich in extendibility. The viewer is developed using Flash, We can operate Flash contents and the JPEG images, and arrange animations in the background. That is why we can create the visual mathematics teaching materials with a viewer. Since editing by "dbook" is possible only by choosing and sticking thumbnail of Flash contents or GCL data. As a result, although "dbook" was developed at first for textbook publishers, it will be marketed because the demand by teachers is very high.



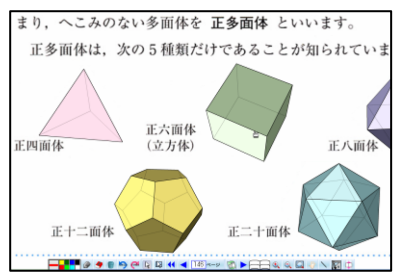


Figure.12. The situation of a lesson

Figure 13. Rotation of the drawn figure

Figure 14. Rotation of the solid through dragging

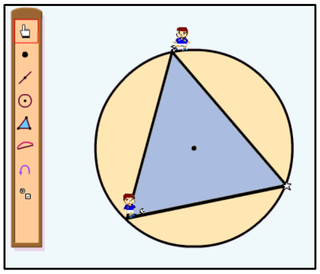


Figure 15. The use of animated cartoon character

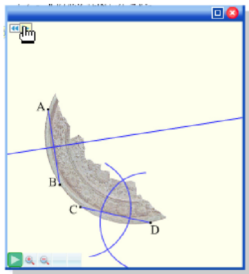


Figure.16. A background image

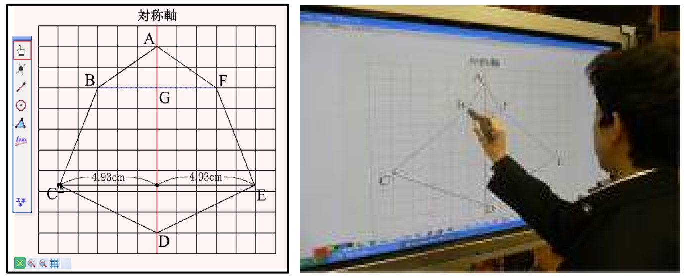


Figure 17. Operation with an “electronic information board” of a GCL teaching material

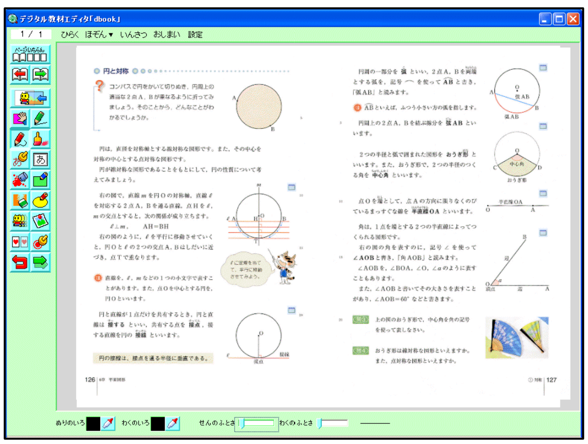


Figure18 An editing screen with dbook

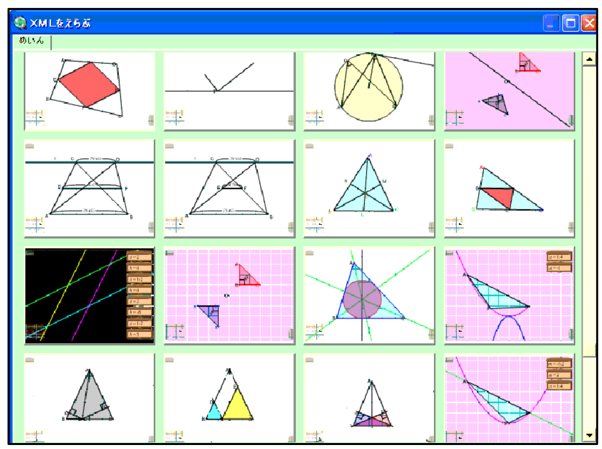


Fig.19 A thumbnail of the GCL teaching materials

Developing Website for Advanced Study beyond Curriculum

Japan has a National Curriculum and lesson hours for mathematics are restricted. From the viewpoint of equity principle, each school develops its own curriculum but it is not easy for school teachers to develop their own curriculum and textbooks. For supporting teachers who have a wish to develop teaching programs beyond their curriculum or to teach mathematics more meaningfully, and for supporting students who are eager to study more, the Japanese government has been offering the national grants for developing such contents. But basically, developed contents have been offered for free. Based on this policy, there are a lot of free contents available on web in Japanese. The National Information Center for Educational Resources (NICER) integrates all resources for education. In the area of middle school mathematics on NICER, the number of contents registered from *GC world* developed by Iijima is the largest. For high school mathematics on NICER, the number of contents registered from the website called *History & Cultural Museum in Mathematics and For All project* developed by Isoda, is currently the largest.

History & Cultural Museum in Mathematics

History & Cultural Museum in Mathematics (figure 20) is a virtual museum on web. It has a lot of original contents with movies and Java. It also includes Japanese translation of the website of University of Modena by M. Bussi which is one of the largest virtual museum websites in the world.

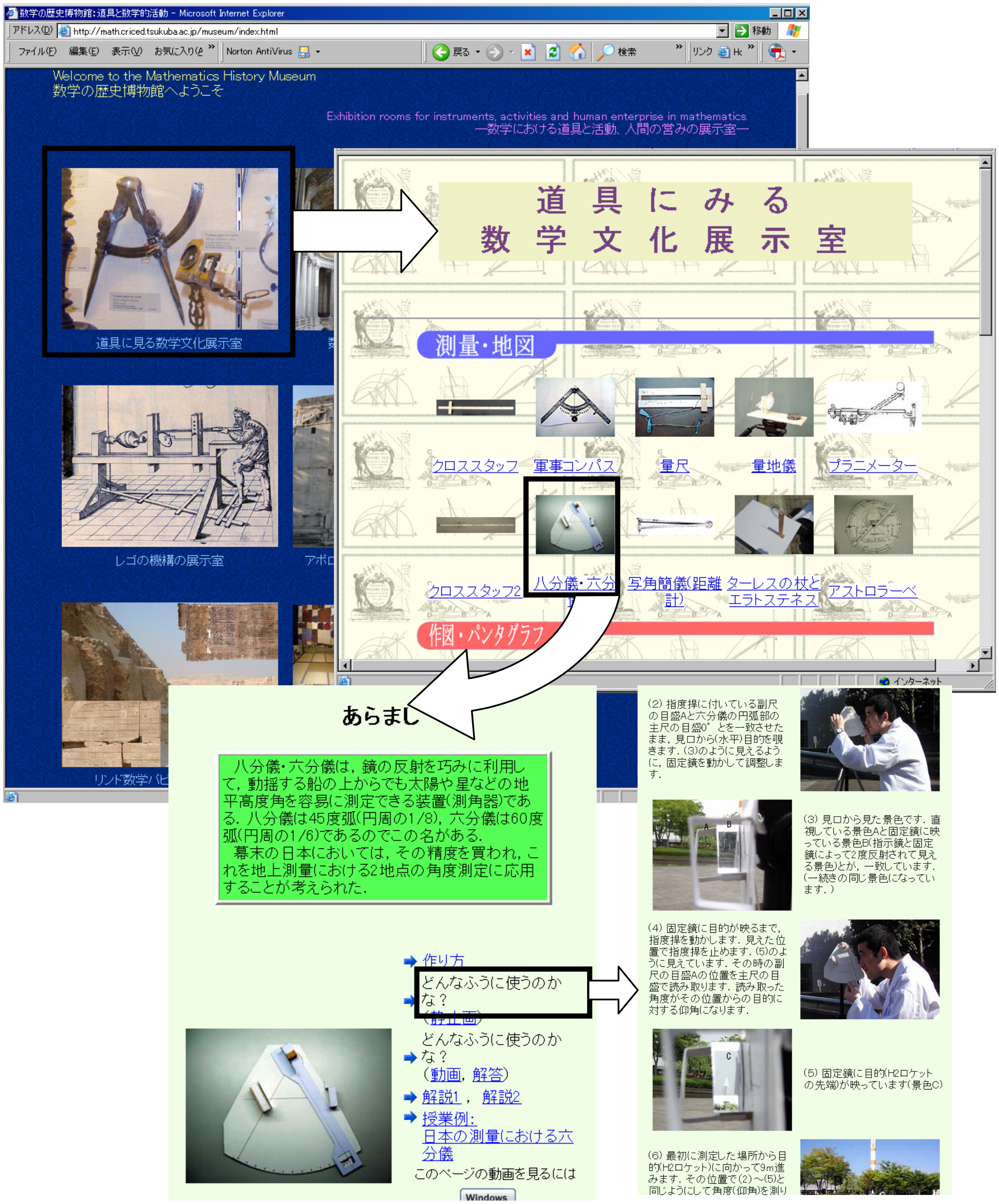


Figure 20. The Website: Mathematics History Museum
http://math.criced.tsukuba.ac.jp/museum/

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Yoden Y. & Yamanoi K.(2004), Examples of Collaborative learning between schools by using groupware, "An Advanced Educational Usage of IT", Toyokan Syuppan, pp.53-58

Yoden Y. et al (2003), “Certain scholastic ability” cultivated through a network, 21th century Education Research

Web site:

Study Note (in Japanese)
http://www.kasei.ac.jp/eco/paper/3/sugita0107.PDF

GRAPES (in English and Spanish)
http://www.criced.tsukuba.ac.jp/grapes/
http://www.criced.tsukuba.ac.jp/grapes/es/

Geometric Constructor (in English)
http://www.criced.tsukuba.ac.jp/gc/GCWorld.htm

Math on Projector (in Japanese)
http://www.culture-pro.co.jp/mop1/menu.html
http://www.culture-pro.co.jp/mop2/menu.html
http://www.culture-pro.co.jp/mop3/menu.html

Mathematics History and Cultural Museum (in Japanese)
http://math.criced.tsukuba.ac.jp/museum/

National Information Center for Educational Resources
http://www.nicer.go.jp/

Mathematics Museum
http://www.museo.unimo.it/theatrum/