e-Textbooks: Advancing Mathematics Teaching and Learning into the Future

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Abstract: For over one hundred years, the environment of mathematics classroom has been supported by chalk & talk teaching style, in which we use blackboard, chalk, notebooks and textbooks. In these days, we can use new teaching styles with computers and LCD projectors, which are being disposed to all classrooms (e-Japan strategy of government). We call it *presentation style* in this paper. In presentation style, we project the textbook to the screen with computer and LCD projector. Comparing to the printed textbook that is static, we can present electronic textbooks (e-textbook) more dynamically. The presentation software such as PowerPoint is a good tool for general use but we believe that we can develop appropriate software for educational use. In this paper, we consider the requirements of the textbook-viewer and develop our software *dbook*, which clears the requirements. The original ideas of the *dbook* had developed through the experience of developing commercial software for the presentation style. With the new developed tool, *dbook*, now, we can develop commercial digital textbooks (e-Textbooks) and many teachers can make their own e-Textbooks by themselves. It will be able to enlarge the presentation style to more interactive way even if teachers use the textbook. At the last part of the paper, we evaluate the power of *dbook* through the two years of experimental use.

1. Introduction

The ordinal style of teaching in Japan consists of a whole classroom teaching with blackboard, chalks, textbooks, notebooks and pencils. It has changed little over the past one hundred years or more. Enforcing the information technology policy, the Japanese government made a plan regarding educational fields. According to it, we can use a computer, a projector and access Internet in every classroom in every school in Japan. This plan aimed to introduce equipment and teaching methods for showing digital contents with projectors into the conventional style of teaching with blackboards. However, the plan accomplished only 25% of total number of schools. The lack of budgets at the country (or rural) areas was a big issue. At the same time, the plan did not attract teachers so much: Some of them claimed "We do not need such tools that require changes in the curriculum" and "We want a tool that accomplishes the present goal of education, easily and rightly". Developing better tools, which are attractive and easy to use for every teacher, are needed.

Consequently, we designed and developed *dbook* as a tool, which can easily combine printed

textbooks and computer mediated interactive educational materials. In this paper, the significance of digitizing textbooks is illustrated in relation to the ways of using printed textbook. An example of the commercial electronic textbook (e-Textbook) which some of the authors have taken part in the development is described. Then, based on this experience, *dbook*, the general e-Textbook construction tool has been developed. Finally, the evaluations of *dbook* are illustrated through the two year experiments at the elementary school.

2. The Ways of Using Textbooks and its Limitations

Teachers use textbooks as their main teaching materials. In conventional classrooms (Figure 1), students have trouble searching to where in the textbook the class is being referred such as where point A and length AB are on the proof in the textbook. Some students cannot follow which parts of the figure the teacher is explaining in the textbook. The following are the possible methods how to show textbooks in the classroom.

2.1. Showing by Posters

Posting enlarged copies of textbooks on blackboards, or purchasing posters (in past *KakeJiku* (Hanging Scroll)) from textbook publishing companies or writing same things on the board are ways to show the textbook on the board. However, there is still disjunction between the posters on the blackboard and the textbook in front of the students. In addition, commercially available posters are provided for limited topics, and not all topics.

2.2. Showing by Document Cameras

This is a method of projecting the textbook itself by document cameras. This has advantage that there is no need for teachers to prepare in advance. Teachers can also point with their fingers which are also projected on the screen directly. However, the

Figure 1. Conventional Classroom

distortion of the projected image from the opened textbook disturbs the students' attention, and it is also difficult for teachers to look at the students while adjusting the position of the camera. Over head projector was used in similar way, almost 30 years ago but now it is difficult to find it in schools.

2.3. Showing by Presentation Software

This is a method of showing scanned textbooks by general presentation software such as Microsoft PowerPoint. In the case of the presentation software
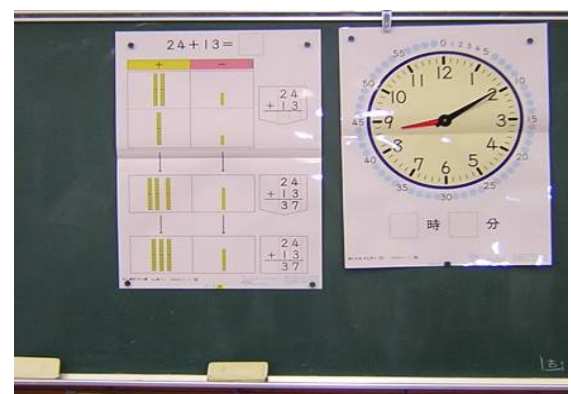

Figure 2. Commercially Available Posters.

such as PowerPoint, we can embed the dynamic contents such as the file of Dynamic Geometry Software (DGS) and video, but the presentation can only follow the developed contents lineally depending on the order of the slides. Teacher cannot change the presentation beyond what he/she expected. For example, it is not easy to enlarge the image shown in the display. Teachers have to talk in lecture style and cannot use the textbook image flexibly according to students' needs.

3. Required Properties for e-Textbooks

Technological tools and environment are selected depending on the aims of teaching and the aims in the curriculum. If the curriculum is embedded in the textbooks, the improving the textbook and the developing the ways of making it more useful for students are necessary. These are the legitimate approaches for the improvement of teaching.

e-Textbook that will be shown on the screen must be visible as well as the textbook in front of students, and at the same time, the teacher (and students) should be able to select the contents according to the flow of the class, and display assisting information for the learning activity. On the presentation teaching style enhanced by the projector in each classroom, e-Textbook will be a preferable way to use computer in the classroom.

The following describes the necessary functions to realize the above requirements.

3.1. Scaling Function and Marker Function

In the e-Textbook, the first entire spread page of the unit of the class must be shown at first so that the students can always understand where the teacher is pointing out in the textbook. The contents in the e-Textbook should be able to be scaled easily so that it is possible to zoom in the focused area in a page, and zoom out before moving to another area, and so on. In addition, the marker function for highlighting items to be focused, and providing parenthetic explanations should have sufficient functions corresponding to general drawing software (Figure 3). With this, the students can rapidly understand the assignment, and assure time to think and comprehend.
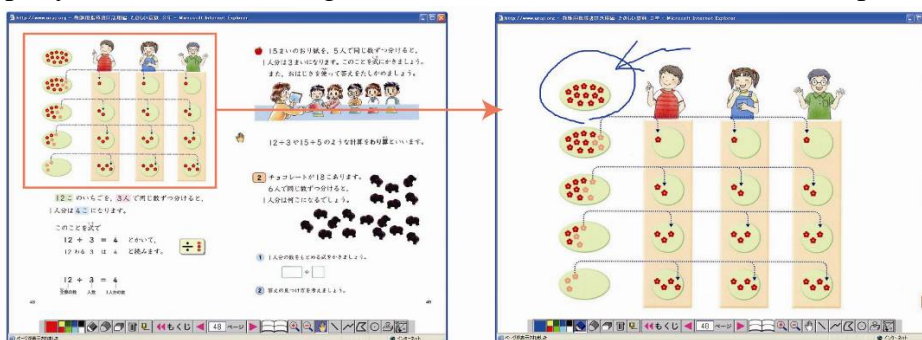

Figure 3. Enlarged Display of the Textbook and the Use of Marker Function.

In textbooks, introduction, problem, hint, commentary or summary and exercise are described conforming to the class' flow, and teachers often want to show them sequentially. In conventional classes, teachers write the problem (or exercise) on the blackboard and ask questions to the students

while the textbook is closed. If it is possible to magnify only necessary portions of the textbook and mask the unnecessary areas, such inconveniences are dissolved, and the students can always look at the image of the textbook while working at the problem. Since recent textbooks are developed for students to write important points into them, the function of masking the important points and showing them later is very effective.

3.2. Dragging or manipulative materials embedded in the e-textbook

Learning activities using animations to support students' comprehensions and simulations of experiments are representative examples of introducing computers into educational fields. Conventional computer mediated classes use proprietary software, but if it is possible to attach these contents on the shown textbooks, the students will not be disturbed by launching programs or switching pages and the class can go on more smoothly. In doing so, it is preferable that the figures and photographs shown in the textbooks can be moved or manipulated by using a mouse.

For example, in mathematics, showing the ways to use triangles by animations would provide effective understanding of the class. In mathematics, it would be useful to show rotations of three-dimensional solids, or simulate the calculation of a car's braking distance.

3.3. Links for to be referred page and external resources

With the link function, digitized reference materials are linked just by clicking it with a mouse. Links not only to pages in the textbook but also to external software are useful for teachers to teach much more materials in class. If it is possible to show contents on the WEB, the teacher can easily use the digital contents that are stocked according to the table of contents in the textbooks provided by NICER (National Information Center for Educational Resources).

4. Developing Commercial e-Textbooks

Most of textbooks' publishing companies have published the different kinds of commercial e-Textbooks depending on the revision cycles of textbooks: In April 2005, the elementary school textbooks were revised and the e-Textbooks on the Japanese, Mathematics, Science, and Society had been published. In April 2006, the textbooks for junior high school were revised and the e-Textbooks for core subjects were published in the same way. Developing experience of the some of them helped to develop the *dbook*. The following is an example of the present e-Textbooks, called *Digi-MATH*, which is a part of a teacher's textbook for mathematics in junior high school, and is developed by one of the authors with the editing department of Gakko Tosho co., Ltd.

4.1. Viewer of e-Textbooks

The image of the textbook is the digitized textbook, itself. The format of the image is JPEG, and the resolution is 144 dpi. The resolution is selected because the resolution of a typical PC display is 72 dpi, and the double, 144 dpi, is useful for enlargement.

The e-Textbook *Digi-MATH* has the function to enlarge the specified area pointed by a mouse.

This function has a feature to eliminate the outside area by trimming. With this, the teacher can easily show only the parts that are necessary for students.

On the display screen, the teacher can write memos by freehand directly using a pen or marker function, and can draw figures such as rectangles and circles. The drawn lines and figures can be moved, rotated, linear symmetry moved, and scaled by dragging the mouse. Moving the center point is also possible (Figure 4).
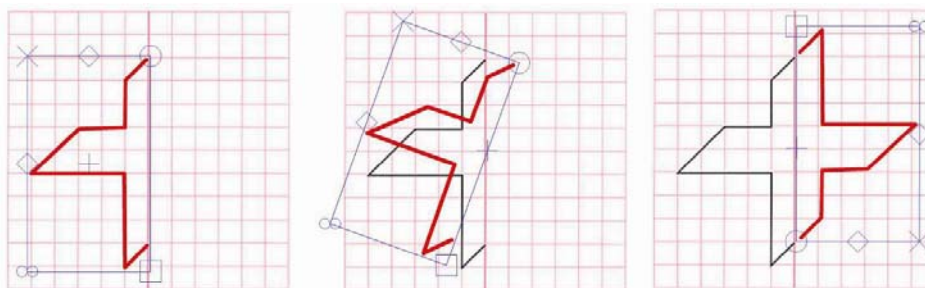

Figure 4. Tracing and Rotating Figures.

It is possible to save the writing and drawing on the *dbook* for the next lesson, not like that for the blackboard. This feature enables teachers to start from the very end of the last class.

4.2. Interactive Contents

In *Digi-MATH*, both the animating educational materials and the interactive educational material, such as the figures in the textbook that can be manipulated directly by a mouse, are available as the "motion contents".

4.2.1. Animation

In the case of *Digi-MATH*, the animation is embedded in the introduction of a unit for making interest to approach the introductory problem of the unit.

Figure 5 shows a problem to find shapes such as triangles and squares from the tessellated shapes like kaleidoscope. In the printed textbooks, only the page in the left side of the figure 5 is existed. By overlapping an animation that paints colors on the shapes, the students will easily understand that there are many kinds of shapes inside the paved shapes with strong interest.

Figure 5. Animation at an introduction page

4.2.2. Direct Operation of the Figures in the Textbook

In the printed textbooks, the students had to imagine the movements of figures by looking at the "before and after" figures. By realizing operations such as parallel, symmetric, and rotational movements directly by dragging a mouse, the students can easily understand the image of the movement.
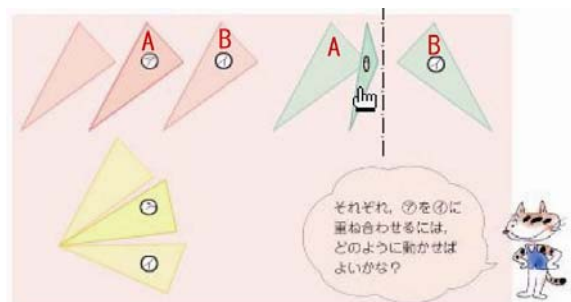
Figure 6 shows a figure of a printed textbook, and the remaining ones show the parallel, symmetric, and rotational movement of a triangle. In *Digi-MATH*, it is possible to drag and move the shape indicated by the symbol "A" in the figure to the one indicated by "B" with a mouse, and to move it back again. By demonstrating this operation repeatedly, the students can make clearer image of the movement.

Figure 6. Direct Operation of the Figure in a Textbook.

4.2.3. Animated Description for Drawing Figures

The animation enhances students' comprehension in explaining methods of drawing figures. In addition, if the teacher shows the animation repeatedly while drawing, it would give support to students who cannot understand by only static figures.

Figure 7 shows the animation of drawing perpendicular line PQ to the line AB by using a compass shown in the textbook.
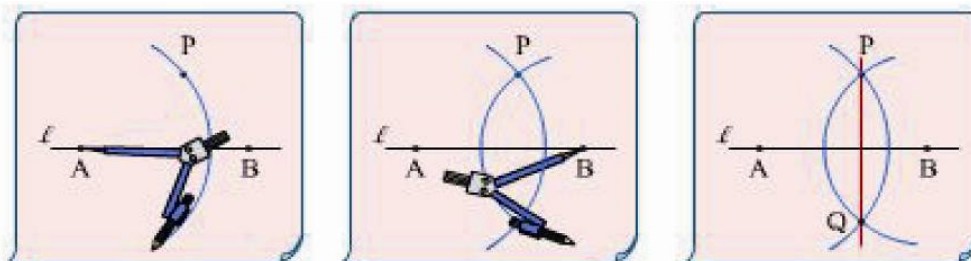
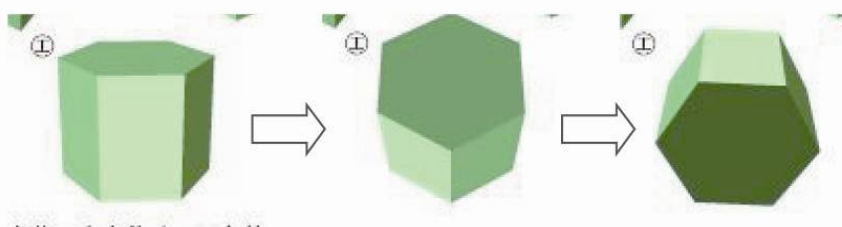Figure 7. Animated Presentation of the Methods for Drawing Figures.

Figure 8. Rotation of Three-Dimensional Solids.

4.2.4. Rotation of Three-Dimensional Solids

Understanding features of three-dimensional solids is possible by rotating the figures and observing them from various angles. The rotation is manipulated with dragging. Figure 8 shows a

vertical rotation of a hexagonal prism with a mouse. Here, the space figure is shown as a three dimension graphics by polygons, and can be rotated in arbitrary directions by mouse operation. The teacher can show the figure of the textbook in real style and by interactive manner.

4.2.5. Introducing GCL Contents as Geometric Teaching Materials

Many contents made with Geometric Construction Language (*GCL*), a kind of DGS developed for e-Textbook are embedded in *Digi-MATH*. The GCL is a description language based on XML which has been developed by the authors with support by one of author, Yasuyuki Iijima.

Figure 9 is a screen shot of *GCL* Editor, an editor which enables constructing figures by mouse operation, and outputting *GCL*. In *Digi-MATH*, *GCL* contents are shown by a viewer implemented with Macromedia Flash, described as "Flash" as follows. Flash provides excellent visual expressions such as overlapping different colors, drawing different-width lines, and implementation of Flash movies. The viewer provides basic functions for a figure-constructing tool, and by dragging the drawn vertex of a figure with a mouse, information such as each interior/exterior angle of the figure and the area of the figure is shown immediately as the figure is changed. Drawing ad joint lines is also possible.
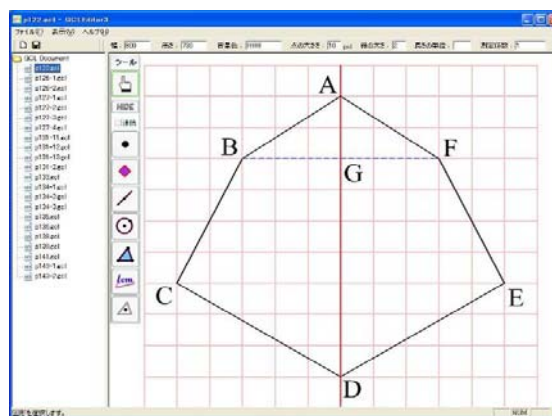

Figure 9. An Example of Definitions of Figures by GCL and Its Presentation

4.3 Links in the e-Textbook

Links to taught contents and learning materials related to the specified items in the textbook are provided by *Digi-MATH*. It does not provide links for external software. The representations in the textbook are the learning material in mathematics at school level, and thus, consistency from basic to advanced learning materials is required. The textbooks of social science and science do not have this property, thus easily provide links.

5. e-Textbook Editor: *dbook*

From the previously mentioned experience of making e-Textbooks based on commercial textbooks, the authors developed *dbook*, a tool which helps teachers to make e-Textbooks easily. The following mentions about the motive of the development and basic operating procedures.

5.1 Motive of the Development of *dbook*

Although many textbook publishing companies have developed e-Textbooks, many of them do not easily achieve the favorable balance. Thus, the limited number of the e-Textbooks are published in tremendous number of textbook series. The development cost for e-Textbook is expensive: for example, in the case of Japanese, to use the texts from literature needs to clear copyright of original

authors. Copyright process for the figures shown in the textbooks is also serious problem. Some figures in textbooks allowed to use only for printed textbooks and did not allow for e-Textbooks.

However, Copyright Law in Japan makes an exception that the teachers can make copies of the book if they use them only in their teaching class. In other words, e-Textbooks made by teachers for their own classes are legal. Thus, a tool for teachers who are weak at computers to make e-Textbooks easily is important. This is the motive of developing *dbook*.

5.2 The Procedure of Constructing e-Textbook

First, the pages used for the class are scanned into JPEG graphic files. The names of the files include consecutive numbers corresponding to the page numbers. The files are selected by the first and the last page numbers and are put into *dbook*. Then, a Flash file, whose extension is "swf", is obtained by selecting "Output Digital Material", from the menu. This is the e-Textbook made from *dbook*. Since this operation is simple, it takes about 20 minutes to make an e-Textbook from a booklet consisting of 100 pages. This e-Textbook is inferior to the one provided by the textbook publishing companies because the latter one provides clearer image and motion contents. However, digitized teachers' handout sheets and workbooks are thought to improve the class greatly.

5.3. Adding Contents to e-Textbook

Each page of *dbook* can include image files, Flash files, and links to other pages or Web pages. In addition, an image file shown on a Web browser can be pasted on the page by drag and drop operation. A link to the Web page can be pasted on it in the same manner. Especially, Flash files, such as animations, give attractive effects to *dbook*. If the teachers purchase Flash and learn how to operate it, which is not easy for all teachers, they can make Flash files as a teaching material. Even if they cannot use Flash, many Flash contents made by skilled teachers are available at Web sites. The GCL contents, teaching materials for figure construction made by GCL editor, are also past on the page of *dbook*.

6. Experiment in Classroom

The elementary school which one of the authors belongs to introduced *dbook* 2 years ago. The average age of the teachers is the latter half of 40's. The PC operation skills of most of teachers are lower than the average. One third of the teachers have changed in the last 2 years. Despite the above circumstances, classes using *dbook* is being established year by year. The teachers who move to the school because of personnel changes can master *dbook* in a few weeks. Figure 10 and Figure 11 shows the ways of using in the mathematics classroom at the school.

In December 2005, attitude of 5th and 6th grade students in the elementary school, including 38 students in total, was surveyed at mathematics class, where *dbook* is used most frequently in the school. Figure 12 shows the result. This says that the cases with *dbook* give better impression than those without it at all items. Especially, 87 % of students think strongly that *dbook* is necessary in

mathematics class. The survey also asked the students about advantage of the class with *dbook*. They said that teaching materials and explanation are easy to understand at the class with *dbook*.

Figure 10. Using *dbook* on the interactive display as well as the blackboard in classes
Both the teacher and students are using the textbook on the interactive display that enables them to write the screen. They can use it as the expanded blackboard for their communication.
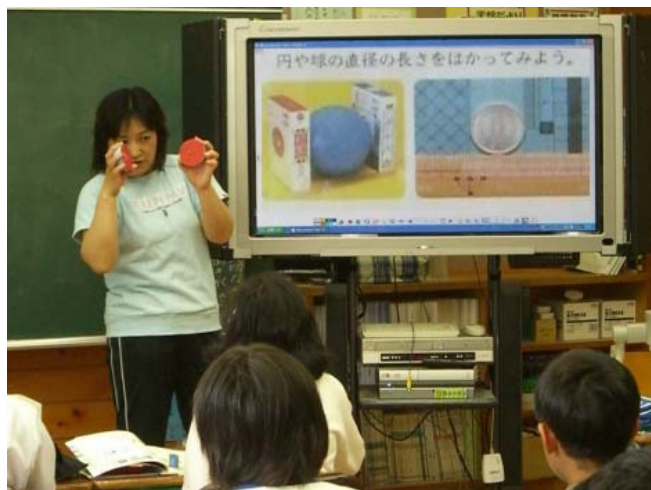

Figure 11. Explaining with Real Material and Textbook on *dbook*

The display shows the scanned pictures of the textbook by *dbook*. Teacher poses a problem of the length measurement using concrete object and *dbook*

7. Conclusion

Adoption of information technology in education driven by the government promotes e-Textbooks as a presentation type teaching material. The authors have examined useful functions for enhancing the students' comprehension of class through development of commercial e-Textbooks. Since e-Textbook did not diffuse because of financial problems, the authors have developed *dbook* which helps teachers to make e-Textbooks. The survey of teachers and students who use *dbook* says that *dbook* is effective. Considering the environment where PC is provided to
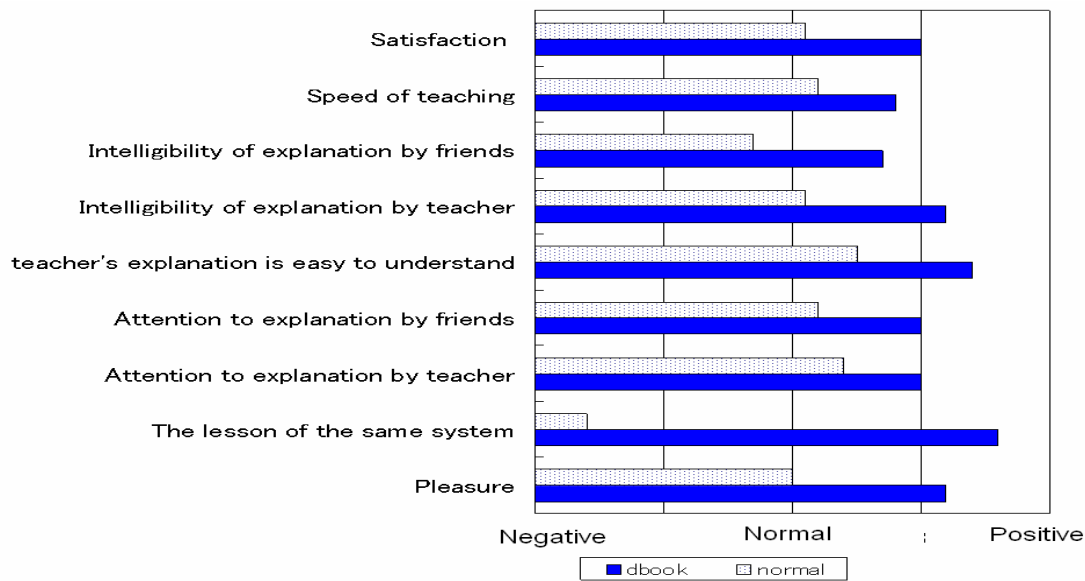
Figure 12. Survey on *dbook* in Mathematics Class.

each student, future study remains in improving e-Textbooks so that the student can use them at any places, such as at home.

The limitation of *dbook* is deeply related with the presentation style teaching because it is developed for it with one projector, one computer and Internet connection. The projector is a part of classroom environment. For overcoming the limitation, we developed the way of using by students on Figure 10 and Figure 11 as well as other equipment in classroom. In their classroom, students and teachers used *dbook* on the display as the expanded blackboard. We can say that the interactive display with *dbook* is a kind of communication tool in classroom which expands the ways of explanation by students and teachers in Figure 12 and one of necessary equipment which will be used in the classroom as well as other conventional equipments: blackboard, chalks, textbooks, notebooks, pencils and so on. In the process of technological innovation, we are supposing to develop into the advanced versions.

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