# Standalone web application for teachers to create teaching materials on a browser

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#### Abstract

Due to the influence of the new corona-virus, the need for ICT education in elementary schools, junior high schools, and high schools is increasing. Currently, the introduction of IT equipment such as personal computers and tablets is progressing in these schools.

However, to realize effective ICT education, software as well as hardware is also an essential element, and it is said that the software is not as complete as the hardware. Although there are some practical examples of ICT education, it is hard to say that it is being used in school education, mainly because of problems with cost and system flexibility.

In order to spread educational activities utilizing ICT, this paper proposes a standalone web application that allows teachers of schools to create teaching materials on the most of modern browsers. Our system is able to create various teaching materials flexibly, and it is easy for school teachers to create their own materials including auxiliary teaching materials used in classes and e-learning teaching materials for exercises. This paper gives some examples of creating teaching materials for class lessons. This paper also presents teaching materials that can also be used as programming exercises where figures created with Cinderella are manipulated with JavaScript and CindyScript codes.

### 1 Introduction

With the rapid development of ICT technology, the demand for educational activities that utilize it is increasing every day. IT devices such as PCs and tablets are being introduced into classrooms, but it is hard to say that the software environment is the same compared to the hardware situation.

In view of this situation, the authors proposed in [1] a standalone web application, with which school teachers can create e-learning system by themselves. Since the system is standalone web application and runs on the most of modern browsers, students can use the created e-learning system from their own smartphones or tablets. In this paper, we propose an extension of the e-learning system in [1]. The proposed system is also a standalone web application as in [1], which allows teachers to create teaching materials on the most of modern browsers. A feature of the new system is the flexibility of its construction. The system in [1] is specialized for e-learning, and the layout of the text areas for entering question sentences and answers is fixed. In the new system, it is possible to freely arrange figures, explanation documents, and text areas for entering answers. In addition, information such as the coordinates of the points in the figure and the character string entered as the answer by students can also be accessed, and data exchange can be arranged freely using HTML5 and related technologies. In this paper, we explain these components through some examples of teaching materials.

This paper is organized as follows. In Section 2, we briefly describes the specification and requirements, and explain each component of the system. We also explain the difference of our web application from the previous one in [1], and discuss usefulness of our web application. In Section 3, we will actually create some teaching materials using the system. Lastly, in Section 4, we conclude.

## 2 Specification and requirements

#### 2.1 HTML5 and related technologies to improve learning experience

With the development of HTML5 and related technology, the study to utilize them to improve learning experience is being conducted. For example, in [2], they present a Blended Learning model that introduces Web application, utilizing HTML5 and related technologies. As the title of the paper indicates, the web application in [2] is designed to run offline, and does not require any server infrastructure nor network connections (in some regions/countries, it might be difficult to prepare them).

In this paper, we also present a standalone (offline) web application based on FOSS (free and open-source software). Our web application runs on the most of IT devices with modern browsers, and can be used in education environments where server infrastructure and network connection are not available.

#### 2.2 System components

First, we describe system components of our web application. The system consists of an HTML file and some JavaScript libraries. It is constructed with HTML5 and related technologies, and various components are provided by the JavaScript library. Some of the components equipped with the system are as follows.

- Editing component The component is provided by Quill (see [3] for details), which is a free, open source WYSIWYG (what you see is what you get) editor written in JavaScript.
- Graphic component The component is provided by CindyJS, which is a framework to create interactive (mathematical) figure that works on the most of modern browsers. With the component, the figure created by Cinderella, which is an interactive geometry software, can be embedded to our teaching materials.

- Algebraic computation component The component is provided by Algebrite (see [4] for details), which is a free open source compute algebra system written in JavaScript.
- Database component Our system utilizes Web storage of a browser as a system database.

We will describe each of these components below.

#### 2.3 Editing component

As mentioned above, our system uses a JavaScript library called Quill ([3]) to add editing functionality. Quill editor has the following features;

- Quill editor enables us to create a menu on a web browser. The menu can be used just as the menu of a word processor such as 'Word', and we can write decorated sentences and figures on the web browser.
- With the menu created by Quill editor, we can use Latex to input beautiful mathematical expressions.
- Quill editor is highly customizable and fits to a wide variety of need.
- With Quill editor, we can also embed figures and videos in our teaching materials.

#### 2.4 Graphic component

Cinderella is an interactive geometry software that has the following features;

- Cinderella lets us create and manipulate visualizations in an intuitive and powerful way.
- Cinderella is equipped with CindyScript, which is a high-level programming language that allows for fast and flexible interaction scenarios.
- It is possible to convert a figure created with Cinderella to an HTML file and view the figure on the most of modern browsers.

CindyJS is a JavaScript library designed to be compatible with Cinderella, providing a set of geometric operations. By using CindyJS, as is shown later, figure created by Cinderella can be embedded to our teaching materials.

#### 2.5 Algebraic computation component

Algebrite ([4]) is a lightweight Computer Algebra system written in JavaScript, which has the following features;

- Algebrite has all basic features of computer algebra system, arbitrary-precision arithmetic, polynomial and rational function computations, differentiation and integration of functions, simplification, matrix and tensor computations, and so on.
- Algebrite is self-contained and does not require a network connection.

• Algebrite is written in JavaScript and can be embedded in other applications and extended with custom functions.

Algebrite is embedded in our system, which enable us to perform algebraic computation in our system. This component is useful in e-learning and so on.

#### 2.6 Database component

The component is provided by Web storage, which is a new technology introduced in HTML5. In short, Web storage is a mechanism for saving data in the user's local environment (browser). Operations such as saving, overwriting, deleting, and clearing all data can be performed using JavaScript. By using Web Storage, it is possible to provide customized information for each user. This mechanism is similar to a cookie (HTTP cookie), but the amount of data that can be stored is larger than that of a cookie. This database component is useful for storing data such as each student's e-learning score.

#### 2.7 Difference from the previous system

In [1], we present a standalone web application based on HTML5 and related technologies, which allows teachers to create e-learning system. The web application in this paper can be viewed as an extension of the one in [1], and is equipped with the following features that the previous one did not have.

- We can flexibly place components (figures, explanation documents, and text areas for entering answers) on each page of each material. This feature gains the freedom of teacher's expressiveness.
- We can place multiple plots (Cinderella figures) on each page of each material. This feature gains the interactivity of the resulting materials.
- We can manipulate the coordinates of points or lines in the Cinderella figure with CindyJS or JavaScript codes. This feature allows us to add programming elements to our teaching materials and makes some systematic construction of the materials much easier.

#### 2.8 Usefulness of our web application

Let us evaluate the usefulness of our web application from the standpoints of students, teachers and school/administrators.

• Student's standpoint – The first advantage of our web application is that students can learn using the system anywhere, using their own smartphones or PCs. The second advantage is that students can move the figure constructed with graphics component (Cinderella) by themselves using the mouse and fingers, so it is possible to perform trial and error while moving the figure. On the contrary, the disadvantage is that the web application runs on its own smartphone or PC, and consumes resources such as CPU power and memory.

Go to Test mode			
dmin menu : Save			
Function	Name	Place	Option
Insert radio button		After ~ basis	Choice A,B,C
Insert textarea	t1	After ~ basis	Row: 10 Col.: 80
Insert Cinderella	c1	After ~ basis	
Insert Quill	q1	After ~ basis	
Insert Javascript button	j1	After ~ basis	label: Execute Row: 10 Col.: 80
Delete	test1		

Figure 1: Editing mode menu

- Teacher's standpoint Our web application let teachers create their own teaching materials (including e-learning materials) that suit their class. On the contrary, the disadvantage is that teachers have to make your own teaching materials. Another disadvantage is that our web application is not a server-based system like Moodle, so teachers have to manage their student grades and learning history themselves.
- School/administrator's standpoint The advantage is that our web application operates standalone, so there is no need to prepare an environment such as a server nor network connection. On the contrary, the disadvantage is that the learning activities using our web application is difficult to administrate from the standpoints of school/administrators, because it is up to each teacher to create teaching materials and manage the learning history of students.

## 3 Illustrative Examples

#### 3.1 Creating explanatory documents

In this section, we will illustrate how to use the system, creating some teaching materials. First, let us construct teaching materials which can be used in a lessons teaching how to draw an equilateral triangle. Completed teaching material is shown in Fig. 4, which runs on a browser of smartphones and PCs (points A and B of the figure can be moved with a mouse or a finger)

Let us explain how to construct the teaching material step by step. Starting the system, we see 'editing mode menu' in Fig. 1. This 'editing mode menu' is a new feature introduced in our new version of web application, with which we can flexibly place components (figures, documents etc) on the teaching materials. The meaning of each button in 'Function' column is as follows;

- 'Insert radio button' This button creates a radio button on the browser screen. The choices for the ration button are specified in 'Option' column.
- 'Insert textarea' This button creates a text area on the browser screen. The numbers of columns and rows are specified in 'Option' column.
- 'Insert Cinderella' This button creates a button on the browser screen. By clicking the button created, we can embed figure created by Cinderella into teaching materials.



Figure 2: Figure created with Cinderella

- 'Insert Quill' This button inserts Quill editor where you can write a text and embed figures and videos.
- 'Insert Javascript button' This button inserts a text area to write a JavaScript program and a button to execute it. The size of the text area, the label of the button, etc. are specified in 'Option' column.
- 'Delete' This button deletes the parts such as radio buttons and text areas created with the above buttons. We specify what to delete by its 'Name' field.

Let us create a teaching material that explains how to draw an equilateral triangle. The following steps are required for this work.

- 1. Create a figure to explain the process of creating an equilateral triangle with Cinderella, and save it as an HTML file.
- 2. Click 'Insert Cinderella' button to create a button to embed the Cinderella figure into teaching materials.
- 3. Embed the Cinderella figure into the teaching materials by clicking the button created in step 2.
- 4. Insert the Quill editor into the browser screen by clicking 'Insert Quill' button.
- 5. Using the Quill editor, write a document explaining how to make an equilateral triangle into the browser screen.
- 6. Click 'Save' button above to download the completed teaching material.

We will explain the above steps one by one with figures. In step 1, we create a figure in Fig. 2 with Cinderella. After saving the Cinderella figure in HTML format, we perform step 2 and 3 of the above steps, and embed the Cinderella figure on the browser screen, which is shown in Fig. 3. Next, in step 4, we click 'Insert Quill' button and Quill editor inserted into the



Figure 3: Cinderella figure embedded into teaching material

browser screen. Using the Quill editor, in step 5, we add an explanatory document to the teaching material and complete the teaching material. Completed material on the browser screen is shown in Fig. 4. Since Fig. 4 is in 'editing mode' (the mode for constructing teaching materials), extra items such as the Quill editor menu in the teaching material are also displayed. When editing mode switches to the test mode by clicking 'Go to test mode' ('test mode' is the mode where students use the teaching material), the extra items disappear as shown in Fig. 5

Lastly, in step 6, we click 'Save' button and download the completed teaching material. The materials can be viewed on the browser as shown in Fig. 5. Note that the points and straight lines in Fig. 5 are drawn by CindyJS, and they can be moved freely with the mouse on the browser. This can lead to a teaching material where students learn through trial and error process.

#### **3.2** Adding programming elements

Recently, programming education has been promoted in Japanese public schools, and it has already been incorporated as part of the curriculum in elementary schools. However, it is difficult to add lessons of programming to the lessons that have already been conducted, and, in our view, lessons that only carry out programming are of little significance (we believe that it is important for programming education to work with other regular subjects such as mathematics and science). Considering such a situation, we consider adding a programming element to the teaching material created above. More specifically, we consider adding a CindyScript program that manipulates the vertices of the equilateral triangle in the teaching material created above. This means a fusion of math and programming lessons, which is considered meaningful in terms of both the number of lessons and the quality of the lessons.

Generally speaking, it is difficult to get the coordinates of the vertices of the Cinderella fig-

	Name	Place	C	ption
Insert radio button	r1	After 🗸 basis	Choice A,B,C	
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Insert Cinderella	c1	After v basis		
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	J <sub>x</sub> I	* teral triangle and radius AB. circles as C, draw a lir	e segment from points A and B to	o point C.

Figure 4: Completed teaching material on the browser screen in editing mode



Figure 5: Completed teaching material on the browser screen in test mode



Figure 6: Text area for JavaScript code and button to execute the code

ure embedded in the web application from the web application. Because, for this purpose, it is necessary for CindyJS (the programming language of Cinderella) and JavaScript to communicate and cooperate with each other. Therefore, in our web application, the following functions are prepared.

- exe\_cs('com') JavaScript function that executes CindyJS command string 'com'.
- js\_to\_cs('cyname', 'jvar', 'cvar') JavaScript function that copies the value of the JavaScript variable 'jvar' to the variable 'cvar' on Cinderella named 'cyname'.
- cs\_to\_js('cyname', 'cvar', 'jvar') JavaScript function that copies the value of variable 'cvar' on Cinderella named 'cyname' to JavaScript variable 'jvar'.

Now, let us explain how to construct the teaching material that manipulate the equilateral triangle. First, we open the above teaching material and click 'Insert Javascript' button, creating a text area and a button that are shown in Fig. 6. When we click the button labeled "Execute" in Fig. 6, the JavaScript instructions in the text area will be executed.

For example, suppose that we want to set the coordinates of point A in the figure to (x, y) = (0, 1). To do this, we need to execute the JavaScript command exe\_cs("c1", "A.x=0; A.y=1;"), where "A.x=0; A.y=1;" is a CindyScript instruction that set the coordinates of point A to (x, y) = (0, 1). Hence, it is enough to type exe\_cs("c1", "A.x=0; A.y=1;") in the text area and click the button labeled "Execute".

Let us show another example. Suppose you want to generate a random equilateral triangle. In this case, we need to execute the following JavaScript command.

x=ranint(0,3);y=ranint(0,3);js\_to\_cs("c1","x","A.x");js\_to\_cs("c1","y","A.y");

In the above instructions, command ranint(m,n) is a JavaScript function that returns a random integer number between m and n. Hence, variables x and y are set randomly, and a different equilateral triangle is displayed on the screen each time "Execute" button is clicked.

It is also possible to obtain the coordinates of points on the Cinderella figure. The following JavaScript instructions display the coordinates of the point A.

cs\_to\_js("c1","A.x","x"); cs\_to\_js("c1","A.y","y"); alert("x="+x+", y="+y);

When the above instructions are typed in the text area and "Execute" button is clicked, the web application displays the coordinates of the point A on the screen.

### 4 Conclusion

With the increasing need for ICT education in recent years, IT devices are being introduced in classrooms. Compared to the hardware situation, the software environment has not improved much. In order to improve this situation, the authors proposed a standalone web application in [1], with which school teachers can create e-learning system questions by themselves.

This paper proposes an extension of the web application in [1]. The proposed web application in this paper allows for free placement of radio buttons, text areas, Cinderella figure, Quill editors, etc, and is more flexible than that of [1]. Hence, it can be used to create various teaching materials including e-learning systems. With the new web application, we can manipulate the coordinates of points or lines in the Cinderella figure with CindyJS or JavaScript codes. This feature allows us to add programming elements to our teaching materials.

We illustrated how to use our system by creating a teaching material that explains how to construct equilateral triangles. Moreover, into the created teaching materials, we embedded a text area where we can input and execute programs that manipulates the equilateral triangles. This means that our system can be applied for programming education.

Currently, we are working for two future targets. The first is to increase the number of teaching materials created by our system, and the second is to increase the components of our system by utilizing various JavaScript library.

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