Pictographing-Implementation of a Pictograph Generation Application for Learning Data Utilization

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Abstract: We propose "Pictographing," an application for generating pictographs using pictograms as building blocks. A pictograph, sometimes used synonymously with a pictogram, is a statistical chart composed of illustrations and symbols. This application enables to realize lots of functions, such as learning the concept of quantity related to the contents of elementary school studies, and such as data manipulation by query language or Web API related to the study unit of informatics in junior high schools or high schools.

Keyword: computer science, information design, data utilization, pictograph, pictogram, database, SQL, web API, K-12

1. Introduction

A pictogram is a universal symbolic representation that uses the shape of an object to help understanding the concept of its meaning.

Pictograms are not limited to the area of information design, and if they are organically related to units on programming, modeling, and simulation, etc. they can be a means of reconstructing new information through the appropriate and effective use of information technology. According to this concept, our group has been researching the educational use of pictograms.

Our research group has published the "Pictogramming" series of integrated applications that can learn information design, and programming through the creation of pictograms [1, 2]. We also reported on the implementation of an application named "Human Picsortgram" for learning sorting algorithms using the learner's experiential knowledge [3]. Here, using the seesaw and weights, the sorting algorithm can be learned experientially through the process of arranging the weights in ascending order. These applications are all available freely at https://pictogramming.org/en/.

The statistical processing and data utilization are one of the major topics in informatics. As for this category, we focused on infographics, in which pictograms are used as components, in relation to the historical transition from ISOTYPES [4], which aimed to visualize statistical information at the beginning of the 20th century, to the birth of pictograms.

Jaleniauskiene *et al.* [5] analyzed 132 articles retrieved from PubMed, Web of Science, ERIC, Education Source, Google Scholar, and other databases about the effects of infographics in higher education.

They indicate that the use of infographics in higher education is primarily to improve learner learning outcomes and effectiveness, and that the use of infographics meets the needs of diverse learners. However,

it was noted that providing accurate and reliable information is necessary for infographics to be used effectively. And it concluded that infographics are used primarily as course materials in higher education; that the visual representation of information can enhance learners' self-efficacy and understanding; that they are visually appealing to learners and thus encourage them to learn information more actively and improve learning outcomes, and that infographics can be used as a tool to improve learning. The visual appeal of the information to learners is expected to encourage them to be more active in learning the information and improve learning outcomes.

According to these research's opinion, it is desirable to report on lesson designs and practices combined with pictograms in the areas of statistical processing and data utilization.

Therefore, this paper proposes a pictograph generating application named "Pictographing" that uses pictograms as its components. A pictograph, sometimes used synonymously with a pictogram, is a statistical chart composed of illustrations and symbols. This application enables to realize lots of functions, such as learning the concept of quantity related to the contents of elementary school studies, and such as data manipulation by query language or Web API related to the study unit of informatics in junior high schools or high schools.

Section 2 provides an overview of the application and describes some characteristic functions. Section 3 explains application instruction. Section 4 explains the analysis of lesson using this application. Section 5 summarizes the paper.

2. Implementation

2.1. Overview

Pictographing is an environment for creating statistical charts and graphs focusing on pictograms. Pictographing creates pictographs using human pictograms. Users specify pictogram images imported from an external source or human pictogram's posture.

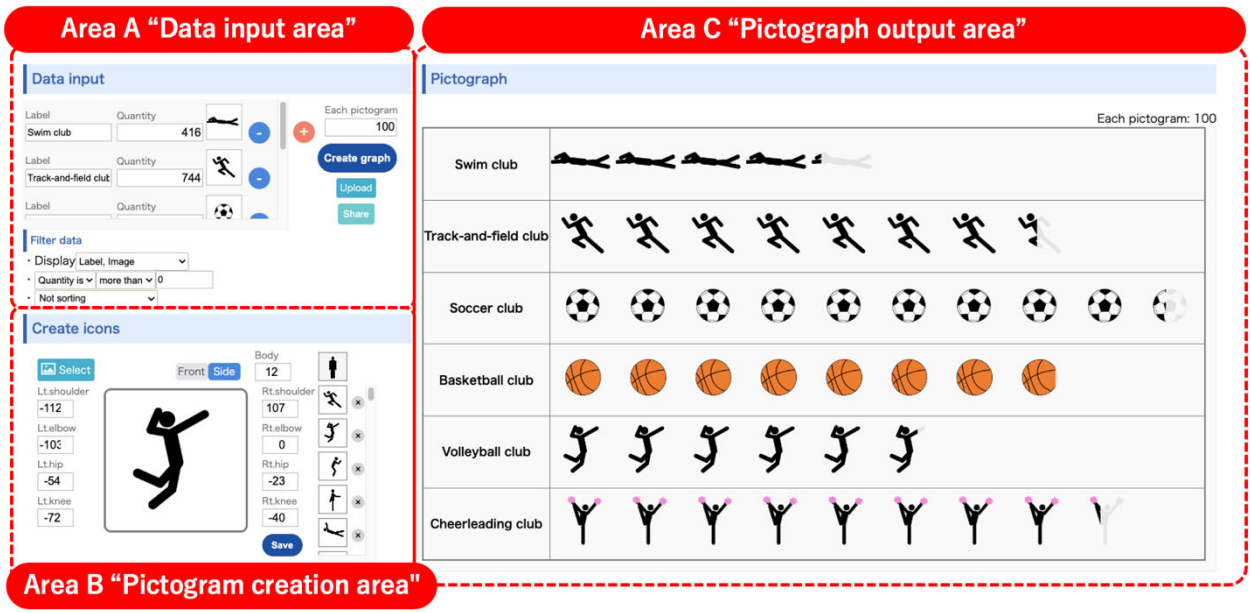

Fig. 1. Screenshot of "pictographing."

2.2. Screen Description

This application is a Web application. Fig. 1 shows a screenshot of "Pictographing." The screen consists of three main areas. First is the "Data input area" (named "Area A" hereinafter). Users inputs the data to be

graphized in the area. Second is the "Pictogram creation area" (named "Area B" hereinafter). Users can create human pictograms' posture in the area. And last is the "Pictograph output area" (named "Area C" hereinafter) where the pictograph is output.

2.3. Data Input Area and Pictograph Output Method

Fig. 2 shows a screenshot of Area A "Data input area."

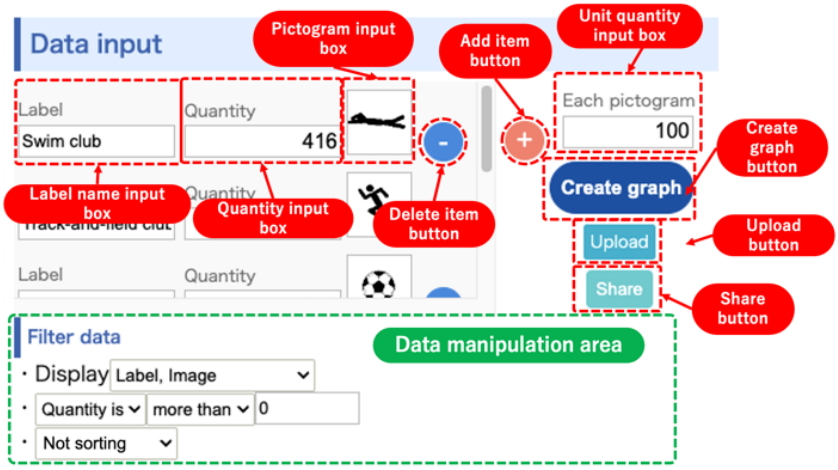

Fig. 2. Structure of Area A "Data input area".

Area A (Data input area) includes several elements: "Label name input box" for entering the label name of item, "Quantity input box" for entering the quantity of item, and "Pictogram input box" for selecting the appropriate pictogram to be applied. Additionally, there are two buttons: "Delete item button" for removing item, and "Add item button" for adding new items to the list. There is also an input box for specifying the quantity of the selected pictogram, "Create graph button" for generating a graph based on the input information, "Upload button" for uploading a text file containing data, and "Share button" that enables users to download text format data file and copy the URL containing data, including a description of the necessary information required to generate a pictograph URL for use in Web API.

The value of "Quantity input box" and "Unit quantity input box" accept non-negative integer and decimal notation. "Add item button" is to add new items. "Delete item button" is to delete the item. The pictogram of each item used to create the pictograph applies the contents displayed on the "Pictogram input box." Clicking the "Pictogram input box," reflect "Pictogram display canvas" in Area B (Pictogram creation area).

The number of pictograms to be displayed on the pictograph is determined from the value entered in the "Quantity input box" (hereafter, "quantity") and the value entered in the "Unit quantity input box" (hereafter, "unit quantity") in Area A (Data input area). First, divide the quantity by the unit quantity, and then output a pictogram with all its integer parts filled in black. The decimal portion is filled with black for the ratio of the decimal value from the left end of the pictogram, and the rest is filled with gray. The example item "Swim club" in Area C (Pictograph output area) shown in Fig. 1 has a quantity of 416 and unit quantity of 100. If the quantity is divided by the unit quantity, the integer part is 4 and the decimal part is 0.16. Therefore, four pictograms are displayed with all filled in black and one pictogram is displayed with only 16% from the left filled in black. The value of the unit quantity is displayed in the upper right corner of the pictogram.

If users don't set the unit quantity, the unit quantity is automatically set according to the number of digits.

Clicking the "Share button" in Area A (Data input area) opens a pop-up window. That allows the user to download the entered data as a text format file. When the user clicks the "Upload button" in the Area A

(Data input area) and reads the outputted data file, the data is automatically input, and the corresponding pictograph is displayed.

2.4. Pictogram Creation Area

Fig. 3 shows a screenshot of the Area B (Pictogram creation area).

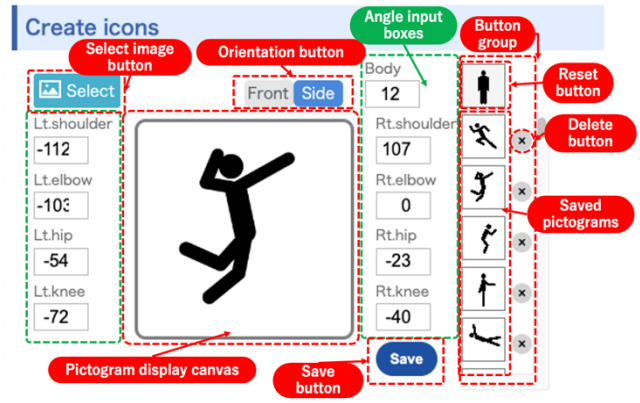

Fig. 3. Structure of Area B "Pictogram creation area".

Area B (Pictogram creation area) consists of "Pictogram display canvas" for displaying pictograms, "Orientation button," which is to select front or side oriented human pictogram, "Save button" for saving the posture displayed on the canvas, "Button group" for calling the saved human pictogram, and nine "Angles input boxes" for entering the angle of each part. The "Angle input boxes" are used to input the angles of each part of the body. The angle input boxes are labeled "body," "Lt.shoulder," "Lt.elbow," "Lt.hip," "Lt.knee," "Rt.shoulder," "Rt.elbow," "Rt.hip" and "Rt.knee."

The "Angle input boxes" is used to input angles in degrees. If the value is a positive number, the angle is rotated counterclockwise; if the value is a negative number, the angle is rotated clockwise. When an angle is entered in the "Angle input boxes," the posture of the pictogram is reflected according to the entered value.

The "Orientation button" allows the user to select the orientation of the pictogram as "front" or "side," and the pictogram is displayed in the front or side design illustrated in the ISO 3864.

Users can save created pictograms. When the "Save button" is clicked, the posture information drawn on the "Pictogram display canvas" is saved in the database. The information to be saved in the database is the values entered in the nine "Angle input boxes" and the orientation information of the human pictogram. Users can call the saved pictograms from the "Button group" in the Area B (Pictogram creation area). When an image of a posture is pressed, the same posture as the image is displayed on the "Pictogram display canvas." The pictogram image of the upright frontal posture located at the top of the button group is the "Reset button." It is to reset the posture of initial state. "Delete button" is to delete the item. To prevent accidental deletion, an alert message is displayed when the "Delete button" is pressed to confirm the deletion. Even after the session is terminated, the saved pictogram data can continue to be used on the same PC with the same browser.

It can use images as the icon for the pictograph. "Select image button" is to select image data file. Users select image data file, it displays the "Pictogram display canvas." It reflects the image displayed on the "Pictogram display canvas" when users click the "Pictogram input box" in Area A (Data input area).

2.5. Database Operation Functions

In the "Data manipulation area," it considers the input data set as a database, and can operate the database according to input, such as specifying columns, and records that satisfy the conditions. This allows

the users to customize the output of the pictograph. The amount of unit quantity in this case is automatically calculated. Displayed columns, conditions, etc. are expressed by multiple pull-downs and text input. Nagataki et al. have developed and published an online learning material that enables learning database operations by expressing the equivalent SQL syntax [6]. This application follows suit, supporting the input of column names and functions such as average, maximum, and minimum values for the quantity of data, corresponding to conditional statements and sorting of values in ascending or descending order.

Fig. 4 shows an example of pictographs generated by entering conditions in the "Data manipulation area" for the pictograph information shown in Fig. 1.

Fig. 4. Example of pictograph generated by entering conditions in the "Data manipulation area".

The upper part of Fig. 4 shows the "Data manipulation area" with the condition that "It displays the label, image, and quantity of records whose number is more than 700. The condition sort by descending order." By default, the label and image columns are displayed. The lower part of Fig. 4 shows the corresponding pictograph.

2.6. Pictograph Generation Function by Access via Web API

When accessing the Pictographing site by URL with parameter, it generates the specified pictograph. Table 1 shows parameters that can be included in the URL.

Table 1. URL parameters

Attribute name	Value Specification
Json	JSON formatted data including item label, quantity of items, and image data
uni	Value of unit quantity
iframe	If the value is "on," only the pictograph is displayed
level	Specifies the functions that can be used (from 1 to 3)

If the json attribute value is specified, it entered its content automatically in Area A (Data input area). If users specify the uni attribute, its value is set to "Unit quantity input box." If users set "on" to the iframe attribute, it only displays the "Pictograph output area." Otherwise, the entire area has displayed like Fig. 1. It is desirable to be able to customize the available functions according to the purpose of learning unit in high school informatics classes. For this purpose, the level attribute can be specified, and Table 2 shows the correspondence of functions according to the level attribute values. The attribute value is specified as a number from 1 to 3. If the level attribute value is not specified, it is assumed to be 1. When the attribute value is 1, it is assumed to be used in the understanding the fundamental topic of pictograph itself, and when the attribute value is 2 or 3, it is assumed to be used not only in the understanding pictograph but

also in the statistical processing and data utilization lesson.

Table 2. Relations between usable functions and attribute value of level

Contents	Attribute Value		
	1	2	3
URL generation function including data information	X	O	O
iframe element acquisition function	X	X	O
Downloading data in text format	X	X	O
Uploading data in text format	X	X	O
Local image selection functionality	X	O	O
Customization of generated pictographs using SQL	X	X	O

The "URL generation function including data information" in Table 2 is a function that allows the application to obtain a URL with URL input data as a parameter. They can start the practice from the state where specific data is loaded by using this URL.

The "iframe element acquisition function" is to allow the users to copy URLs with URL input data as parameters and strings described in the iframe element of the HTML from which the pictograph area is clipped. By inserting this string into a specific area of the HTML source of another Web page, only the "Pictograph output area" generated by this Web service can be embedded. This function is supposed to use for lesson to learn about Web API.

3. Application Usage Procedures

This section describes application instructions in order from section 3.1 to 3.5.

3.1. Accessing Application

At first, access the Pictographing web site. As shown in Table 3 in Section 3.1, the available functions can be set by specifying the level attribute value. To suit their specific needs, users can access by specifying the level attribute.

3.2. Data Input

Users can enter data by three ways: 1. by manual input, 2. by giving URL parameter, or 3. by reading an external text format data file. The data entry procedures for each of the three methods are described below.

- In the manual input method, the users can freely input item labels and quantity in the Area A (Data input area). To increase the number of items, click the "Add item button." To delete a specific item, click the "Delete item button" on the right side of the corresponding line.

After completing the entry, create an icon in the Area B (Pictogram Creation Area). If users wish to use an image from a local file, select the image they wish to use from the "Select image button." If the users are creating one's own human pictogram, one can use the radio button to select the front or side pictogram. After that, the user inputs each part's angle from the nine "Angle input boxes." With the corresponding icon displayed on the pictogram display canvas, click the "Pictogram input button" for the corresponded item in the Area A (Data Input Area). After completing records, enter the quantity represented by one icon in the "Unit quantity input box" in the Area A (Data input area).

- In the case of giving a URL parameter, access the Web page with a URL that contains data information as a parameter. After entering data manually, click the "Share button," and a pop-up window will appear as shown in Fig. 5. Users can copy the URL containing the data from the pop-up

window. It displays the Web page with the data entered when accessing the generated URL.

- In the external text format data file loading, a pop-up window shown in Fig. 5 is displayed when users click the "Share button." After inputting data using 1. by manual input method, users can download text format data file from the pop-up window. By uploading the downloaded the data file and clicking on the upload button located in Area A (Data Input Area), it sets data automatically.
- By giving URL parameter method and 3. by reading an external text format data file method enable students to start the practice, for passing the data entry phase in the lesson.

Fig. 5. Popup window to copy URL or iframe tag, or to download text format data file.

3.3. Pictograph Output

It outputs pictograph on the right side of the screen when users press "Create graph button" after data input.

Users can use creating graph function for understanding quantitative expressions in elementary mathematics, visualizing data, and creating posters.

3.4. Data Manipulation

Specify the level attribute value as 3 and, manipulate data from the data manipulation area in Area A (Data Input Area) with data input.

In the first line, select the column to be displayed in a pull-down format. The eleven options are "Label, Image," "Label," "Image," "Quantity," "Label, Quantity," "Image, Quantity," "Label, Image, Quantity," "Label, Image, Quantity," "Maximum Quantity," "Minimum Quantity," "Average Quantity" and "Total Quantity." The default is "Label, Image."

The second line indicates like "where clause" in SQL, where the extraction conditions are entered. The line consists of three input boxes. The left input box has two options, "Quantity is" and "Label is." The default setting is "Quantity is 0 or more." Users can enter a number or a string in the center input box. The right input box has seven options: "or more," "equal," "inequal," "or less," "more than," "less than," and "match."

A pull down shown in the third line is to sort the selected data. It has "Not sorting," "Sort by ascending order," and "Sort by descending order" options. The default is "Not sorting." When user has set data manipulation area and presses "Create graph button," a pictograph with satisfied records has generated.

3.5. Accessing via Web API

Specify 3 for the level attribute value and, copy the iframe element from the "Share button" in Area A

(Data Input Area) with data input. Users can embed the iframe element generated by Pictographing in the HTML code of their Web pages, and output only the "Pictograph output area."

4. Practical Evaluations and Analysis

4.1. Overview

We conducted experiments to evaluate the effectiveness of this application in four classes of first-year high school students, with 103 students. The lesson was conducted on 13 Feb (Mon) 2023. Each lesson lasted 45 min and used standard PCs. Table 3 describes the overview of the lesson. In the first, a 10-min lecture on the history of infographics and relation to pictograms. And in the last, a 5-min lecture about Web API.

Table 3. Overview of The Lesson

Contents	min
1. Short lecture on infographics	10
2. Exercise on how to operate Pictographing	5
3. Create original pictograph using statistics website	15
4. Exercise on embedding pictograph in HTML page	5
5. Short lecture on Web API	10

4.2. Evaluation and Result

We conducted experiments to evaluate the effectiveness of this application in four classes of first-year high school students, with 103 students. The lesson was conducted on 13 Feb (Mon) 2023. Each lesson lasted 45 min and us

We provided a questionnaire after the lesson. The questionnaire consists of the five questions in Table 4 and the options for each question was "4 = agree," "3 = somewhat agree," "2 = somewhat disagree," "1 = disagree."

Table 5 shows the result for all questions. Table 4 presents excerpts from the free response statements that describe the students' impressions of the lesson and their findings. The respondents are listed in ascending numerical order to maintain their anonymity.

Table 4. Questionnaire List

	Contents
Q1	You learned how to present data.
Q2	You understood what Web API is.
Q3	You understood the procedures of the lesson.
Q4	You understood the purpose of the lesson.
Q5	You were motivated to learn the lesson.

Table 5. Questionnaire Result

	1	2	3	4	Ave
Q1	1	1	39	62	3.573
Q2	3	13	39	48	3.282
Q3	1	0	23	79	3.748
Q4	2	0	21	80	3.728
Q5	1	0	14	88	3.835

Overall, the evaluation of the lesson was well, with the majority of respondents choosing "agree" or "somewhat agree" responses. The questionnaire results for question 1 showed an average score of 3.573,

indicating that the respondents learned how to show data. For question 2, the respondents' average score was 3.282, suggesting that their understanding of what Web API is still needs improvement. The respondents' mean score was 3.748 for question 3, indicating that they understood the procedures of the lesson. Similarly, for question 4, the respondents' mean score was 3.728, indicating that they understood the purpose of the lesson. The survey results for question 5 showed that the respondents' mean score was 3.835, indicating that they were motivated to engage in the lesson.

Since more than 98% of the respondents answered "4 = agree" or "3 = somewhat agree" for questions 1, 3, 4 and 5, it can be concluded that the explanation of the procedures and objectives of the lesson was well conveyed to the students. However, for question 2, 15.5% of the respondents answered "2 = somewhat disagree" or "1 = disagree," indicating that the understanding of Web API still needs to be improved. Therefore, to deepen the understanding of Web API in the lesson, improvements in applications and the use of supplementary lesson materials and exercises are necessary. Table 6 indicates the excerpts of participants' impressions of the lesson and their findings. These comments also reflect the result of the questionnaire.

Table 6. Participants' impressions of the lesson and their findings

	Participants' Impressions
1	Even if I cannot create a website by myself, I can create a good website by borrowing services created by others.
2	If I understand how URLs work, I can incorporate a variety of services into a single site that I cannot create yourself.
3	It was good that I could learn quite complicated things all together while having fun.
4	I learned that infographics are very important, and it was refreshing to understand how Web API works.
5	I enjoyed this lesson very much, I became more interested in HTML, etc. I could understand the API very well. It was a very enjoyable lesson, and I could learn about pictograms and the Web.
6	I heard about Web API in the second half of the lesson, but I didn't understand it very well.
7	I thought it was great that infographics made information easy to understand.
8	The last explanation was so difficult that I could not understand what he was saying at all.
9	I enjoyed it very much. I was able to create easy-to-read graphs by using pictographs.
10	It was great fun to be able to connect the infographics story to the HTML story. I wish there were more lessons like this that covered multiple themes.

5. Conclusion

This paper explains a pictograph generating application named "Pictographing."

In the future, based on the results of the survey, we plan to conduct further investigation and develop improvement plans to enhance the course structure and applications. We also plan to evaluate and analyze the unique features and significance of pictograms in this application.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

KI conceived of the presented idea; RT and KI contributed to the design and implementation of the application; YO performed the lesson and experiments; RT and YO contributed to the analysis of the result. RT and KI wrote the paper; all authors had approved the final version.

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