
Development of Teaching Material on the Web for Computer Programming Education and its Evaluation

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1. Introduction

In university computer programming classes, mathematical type teaching materials are widely used. It is often observed that this type of teaching material makes some students think programming is difficult and they lose their interest in studying programming. Therefore, it has been pointed out that the use of non-mathematical type material might be better¹⁾. In the authors programming practice class, students create animation as programming practice because this type of practice will make students interested in learning programming. This type of animation creation practice is well received by students²⁾⁻⁴⁾.

For the animation creation, we provide students with materials such as fundamentals for creating basic animation, explanations, thereof usage of the information, basic animation creation method, its application and its programming example in printed form (black and white). However, it is difficult for students to see the actual color or motion in printed material, because some of the animation is only shown on the screen and it is difficult for the students to actually reproduce the motion or examine the source code by themselves. In order to overcome those problems, we have developed teaching materials on the web and actually used them in programming practice class. In this paper, we give the general description of programming practice, the objective of developing teaching materials on the web and guidelines for it, a general description of materials their effectiveness and problems we may see in the future.

2. The General description of programming practice

Junior students in social science classes in our university take the programming practice class as shown in Table 1. This class is conducted two times a week. Although the students in this class have some experience in using some software like Excel or Word, they have very little experience in programming. The computer language used in this class is C language, which is widely used regardless of business or technical application field. The Ultra-C Pro is used because it supports

graphics and is easy for the beginner to use. As shown in Table 2, the practice starts with understanding the general concept of programming and moves on to variables, conditionals, looping and iteration, function, array. After understanding those fundamentals, students practice using simple examples and are given animation creation assignments.

After the students study the concept of graphics, how to use graphics function and practice animation creation two times (three hours each), the creation of their original animation is given as a final assignment. Students create their own animation within nine hours (2 classes×3).

Table 1 General description of practice

Number of students	40 junior students
Total hours spent	2 classes (one and half hours each) per week
TA(Teaching Asisstant)	3 persons
Language used	Ultra-C Pro (life board) on the Windows environment
Contents of practice	Programming general, usage of language processing, fundamental of C language, graphics, animation creation

Table 2 General description of practice

1	How to carry out practice, what is programming, algorithm to program and program to algorithm relation, programming language, what is C language, how to use Ultra-C
2	How to use Ultra-C, fundamentals of C language, constant and variable
3	Variable, data type, display on the screen.
4	Input from keyboard, operator
5	Operator
6	Conditionals, looping and iteration
7	How to build function
8	Class and scope for memorization of data, array (value)
9	Array (character), summary of C language, graphics explanation, submit of assignment (print subject, animation creation)
10	Graphics (example of animation)
11	Practice work on assignment
12	Practice work on assignment
13	Practice work on assignment
14	Presentation of finished assignment, filling in a questionnarire for this practice

3. Development of teaching materials on the web and guidelines for this

3.1 Objective of developing teaching materials on the web

We have already made clear in our previous paper²⁾⁻⁴⁾ that animation creation used in this programming practice class made students interested in learning programming, and it helps the students to understand the programming process and what programming is. Because the teaching materials used to explain graphics function were originally provided by Ultra-C and rearranged by the authors, as shown in Fig. 1, they are provided in black and white. The explanation of basic animation creation and its application is also provided in black and white. The reason why black/white printing is used is because color printing takes time and is expensive. Although this kind of teaching material based on printed material has the advantage of easy duplication and can be referred to at anytime, it has the following disadvantages.

- ① The color, which is an important factor in animation creation, cannot be displayed.
- ② It is very difficult to display motion, which is the objective of animation creation.
- ③ It is very difficult to make the program deal with the motion one wants to refer to.
- ④ It is difficult to show the relationship between the program and its related motion.

To resolve these problems, the authors have developed teaching materials allowing students to display color print on their own PC, reference programming example or actual motion and copy and paste on their own PC. These teaching materials are intended to help students create animation.

3.2 Guidelines for development of teaching material

(1) Installation environment

The teaching material to be developed is material on the web. The material is installed in PC server that is shared by clients in practice class. For the operating system and browser, the Window95 and IE (Internet Explorer) Ver. 5.0 or above are used. The computer language used for development of teaching material should be HTML because link function can be easily achieved and this language is widely used. Because the enhancement is expected, software such as homepage builder should not be used. For the portion HTML does not support, Javascript should be used.

- ##### (2)
- The material must overcome the problems which the printed materials have and should be easy for students to use.

3.3 DrawLine 直線を描く

【書式】 void DrawLine(X1,Y1,X2,Y2,色,線の種類,線の幅)

【説明】 始点座標 (X1,Y1) と終点座標 (X2,Y2) を結ぶ直線を描く

【引数】

X1,Y1 ... 始点座標
X2,Y2 ... 終点座標
色 ... 色のマクロ名、または RGB を指定する (2.2.1 を参照)
線の種類 ... 線のマクロ名を指定する(2.2.2 を参照)
線の幅 ... 数字を指定する (2.2.2 を参照)

例 3 いろいろなスタイルの直線を描く

【プログラム 3】

```
#include "graphic.h"
void main()
{
    DrawLine(100, 50, 250, 50, BLACK, PSOLID, 1); /* ㉑ */
    DrawLine(100, 80, 250, 80, BLACK, PSOLID, 2); /* ㉒ */
    DrawLine(100, 110, 250, 110, BLACK, PSOLID, 3); /* ㉓ */
    DrawLine(100, 140, 250, 140, BLACK, PSOLID, 4); /* ㉔ */
    DrawLine(100, 170, 250, 170, BLACK, PSOLID, 5); /* ㉕ */
    DrawLine(300, 50, 450, 50, BLUE, DASH, 1); /* ㉖ */
    DrawLine(300, 80, 450, 80, GREEN, DOT, 1); /* ㉗ */
    DrawLine(300, 110, 450, 110, RED, DASHDOT, 1); /* ㉘ */
    DrawLine(300, 140, 450, 140, VIOLET, DASHDOTDOT, 1); /* ㉙ */
}
```

【解説】

㉑～㉕ 黒、実線、太さ 1～5 の線を描きます。㉖ 青、破線、太さ 1 の線、㉗ 緑、点線、太さ 1 の線、㉘ 赤、一点鎖線、太さ 1 の線、㉙ 紫、二点鎖線、太さ 1 の線を描きます。

(注: ㉑～㉕ 実線以外の線の太さは、1 を指定します。)

【結果】

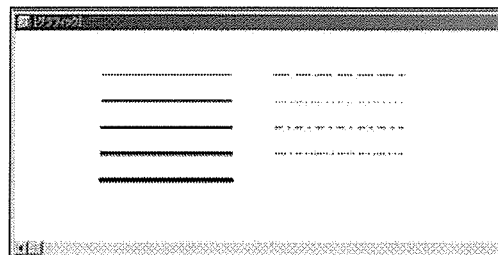


Fig. 1 Printed material sample

4. Development of teaching materials on the web

4.1 Basic structure

Frame structure throughout the material has two frames as shown in Fig. 2. The left side frame has table of contents and right side frame has an explanation or description. The left side frame always has table of contents displayed because it is easy to jump to the page in the table of contents and related pages can be easily referred. Throughout the web page, back screen picture on the description page and layout of the pages have a consistency of style for easy use.

4.2 Overall structure

Because this material is intended to overcome the disadvantages found in printed materials, this material basically follows the style of printed material. Basic graphics, color, explanations of function and animation creation methods are explained more in detail. Furthermore, more abundant colors are used for ease of use. Fig. 3 shows the overall structure of this material. As illustrated in Fig. 3 this material consists of basic figure, color and style of figure, animation, programming example and terminology.

(1) Basic figure

Points that make up basic figures, straight lines, rectangles (rectangles with round corners, polygon), and roundish shapes (circles, ellipses, arcs, bow shapes, sectors) are explained and text drawing methods with graphic functions that are not explained in printed material are explained. In the explanation, the functions and their usage are explained. Because those functions require certain properties for color and style, the meaning of the macro name related to the color of a figure can be referenced whenever required.

Table of contents	Description (includes figures, table, picture etc.)
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Fig. 2 Frame structure

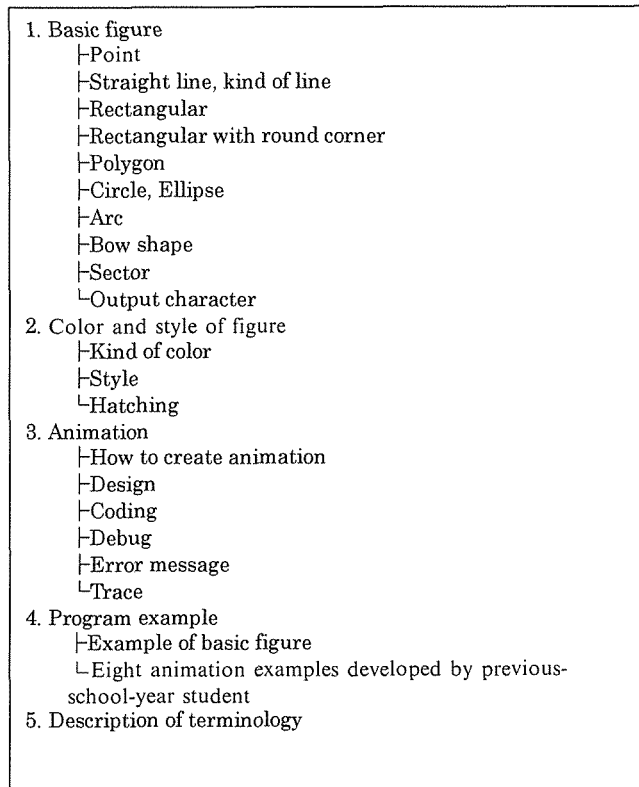


Fig. 3 Overall structure

(2) The color and style of figure

Because lines or figures very often have color, the macro name describes the color of a figure or style in detail so that the color can be easily used.

(3) Animation

Not only static graphics creation but also the animation creation method is explained by using examples. The coordinates of the animation planning, design (including coding), basic procedure like debugging, and iteration that is necessary to move pictures are explained. The animation GIF is used for some animation-motion execution.

(4) The programming example

This material has programming examples with basic figures as a reference to the programming, and eight kinds of source code written by the students who practiced before we developed this material were introduced. The basic figure examples include many examples taken from the programming book and rewritten by us in Ultra-C. These kinds of examples include some that are difficult to master in this practice class; those are prepared for the students who want to study more advanced techniques something we hope students will learn in order to write more compli-

cated source code in the future.

(5) Terminology

Terminology used in programming textbooks or reference books makes first time students who study programming in the university confused; they have no idea what it means. For the ease of understanding terminology used in programming such as “algorithm”, “header file”, “random numbers” are explained in plain sentences. Twenty-four terminology items are explained. More terms need to be added.

4.3 How to use teaching materials on the web

The use of the material is as easy as browsing the ordinary web page. It can be browsed by clicking with a mouse. Because students can not execute the programming example on the web they copy source code and paste it on the Ultra-C Pro file and execute it.

4.4 How the student has access to the teaching materials on the web

Because this material is based on Ultra-C Pro graphics function to assist students to use graphics function and create animation, this material is intended to be used only in the social science class room (called 005 practice room) where Ultra-C Pro is installed and software license is obtained. Because of this, this material is stored in the teaching-materials folder at the file server that can be accessed by faculty and students. Before students studied how to use graphics function for the creation of basic figures and how to create animation by using printed material and start their assignment, this teaching material was presented to them and an explanation was given to the students. After this was done, students could use this material in 005-class room even after practice class, until they completed their assignment.

5. Evaluation

5.1 Installation environment

As stated in the guidelines, this material was installed in the file server in the practice classroom where students practice programming, and this server is connected to client PC used by students via 10-BaseT (10Mbps) through a hub. It was confirmed that client PC could access this material by using IE Ver. 5.0 without any problem during programming practice.

5.2 Evaluation of effectiveness of the teaching materials on the web

(1) Evaluation of effectiveness of the teaching materials on the web by means of a questionnaire

We conducted a survey on the last day of classes for the students who used this teaching material, to determine the effectiveness of it. The contents of the survey were: how well the explanations were understood, how easily this material could be used, whether this material was helpful or not. The results of the survey are shown in Table 3 and Fig. 4. Forty useful responses were obtained from among forty-one students (97.6%).

Table 3 Result of survey

Question	Select	Number of person	Ratio(%)
Which teaching materials did you use when creating animation?	Web material	2	5.0
	Mostly web material	3	7.5
	Half and half	21	52.5
	Mostly printed material	7	17.5
	Printed material	7	17.5
	Total	40	100
How well was the explanation of the teaching material on the web understood?	Easy to understand	23	57.5
	Fairly easy	12	30.0
	Difficult to say	4	10.0
	Fairly difficult	0	0.0
	Difficult	1	2.5
	Total	40	100
Quantity of characters	Too many	13	32.5
	Fairly many	5	12.5
	Difficult to say	19	47.5
	Fairly less	2	5.0
	Less	1	2.5
	Total	40	100
How easily was it viewed on-screen?	Easy to view	26	65.0
	Fairly easy to view	8	20.0
	Difficult to say	5	12.5
	Fairly difficult	0	0.0
	Difficult	1	2.5
	Total	40	100
Was the material helpful?	Helpful	30	75.0
	Fairly helpful	4	10.0
	Difficult to say	3	7.5
	Fairly not helpful	2	5.0
	Not helpful	1	2.5
	Total	40	100

① How frequently this material was used

Table 3 shows that half-and-half use of both printed material and web material was the most common pattern (52.5%). The 35% of students (including 17.5% of students using printed material and 17.5% of students using printed material fairly often) used printed material. On the other hand, the 12.5% of students (including those who used only this material and those who fairly often used this material) used this material. This shows that 85% of students in total have used printed material, and more than 65% of students used this material for more than half of their needs. In this respect, it is assumed that the printed material is well organized in compact form, and web material is referred to supplementarily to overcome the shortcomings of printed material. It is clear that web material is just used to supplement printed material.

② How well the explanations of the teaching materials on the web were understood

As shown in Table 3, regarding how well explanations were understood, 87.5% of students selected “Easy to understand” (including “Easy to understand”, 57.5%, and “Fairly easy to understand”, 30%, totaling 87.5%). Those figures show that the students easily understand this material.

③ Quantity of characters

As shown in Table 3, regarding the quantity of characters, 47.5% of students selected “Difficult to say”, on the other hand, “Too many” totalled 32.5%, and “Fairly many” totalled 12.5%, totaling 45% of students selected. It seems that some pages had appropriate number of characters and some pages had more than the appropriate number of characters for the contents. It seems that this is because those pages were mixed up.

④ How easily viewed

As shown in Table 3, “Easy to view” and “Fairly easy to view” responses totalled 85% in all. This shows that students appreciated the easiness of viewing material.

⑤ How helpful the material was

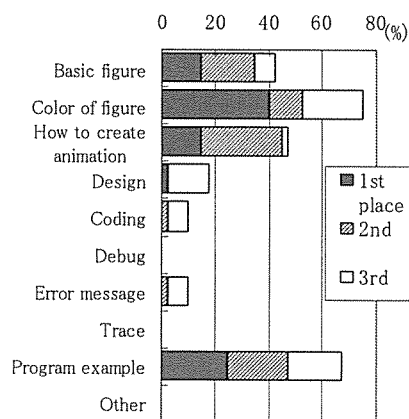


Fig. 4 Result of items viewed

As shown in Table 3, “Helpful” was the response of 75% of students and “Fairly helpful” 10%, totaling 85%. It is clear that this material was helpful for most of the students.

⑥ Items viewed

Fig. 4 shows the frequently viewed items selected in the questionnaire and lists them in frequency order. As shown in Fig. 4, the most frequently viewed item was the color and style of figure (40%), the second one is the example of programming, and the third one is the animation creation method (47.5%) and the fourth one is basic figures (32.5%). This shows that students most frequently viewed the color and style of the figure they want to create.

As seen in the questionnaire, this material is appreciated by the students, and they recognize that this material is helpful for animation creation, easy to use and easy to understand. The reasons why students appreciated this material are:

- ① Animation creation is visually understood in relation to programming example.
- ② The relation between source code and animation movement is easily understood.
- ③ Whenever students need to view source code, they can open the source code, copy it and paste to see the animation movement.

Viewing many programming samples helped students understand what they can do with the programming and put together their ideas. In this respect, it is clear that teaching material on the web was helpful for the students to understand programming and animation creation.

(2) Comparison by number of source code steps

To see how effective this material is, we compared the number of source code steps after this material was used and before this material was used. The number of source code steps is a well known criterion to measure the software productivity⁴⁾, and we use this to evaluate the volume of the programs students have developed. The number of source steps we used here does not include steps such as space line, { } line, comment line. Table 4 shows the number of source code steps before students used this material and Table 5 shows the number of source code steps after students used this material. Fig. 5 and Fig. 6 show the distribution map of source code steps of Table 4 and Table 5 for every ten steps. Table 4 and Fig. 5 show that average number of steps before this material was used was about 40 steps and varies from 7 steps to 120 steps. The largest distribution covers from 20 steps to 29 steps and it has 28.9%, and 97.4% of all distribution has less than 80 steps. Table 5 and Fig. 6 show that average number of steps in the school year after this material was introduced was 129 steps, and this became threetimes of steps seen before this material was introduced. The distribution of steps ranges from 24 to 564 and has wider range compared to the distribution before this material was introduced.

Overall distribution shifted to the side showing a larger number of steps. It is also clear that before this material was introduced, 97.4% covered less than 80 steps, but after this material was introduced, only 34.1% covered less than 80 steps, while 65.9% covered more than 80 steps.

Table 4 List of LOC and FP, and characteristics before this material was introduced

No.	LOC	FP
1	23	5
2	39	4
3	16	4
4	40	3
5	17	3
6	43	8
7	7	2
8	76	7
9	71	2
10	120	15
11	76	11
12	37	4
13	56	5
14	75	15
15	29	3
16	26	3
17	20	3
18	42	7
19	33	2
20	41	7
21	56	6
22	16	5
23	29	5
24	23	6
25	60	9
26	13	8
27	22	4
28	22	5
29	38	8
30	21	7
31	37	4
32	51	7
33	17	9
34	25	3
35	58	4
36	43	5
37	23	8
38	71	3
Average	39.8	5.8
Median	37	5.0
Distribution	555.6	9.9
Range	113	13
Minimum	7	2
Maximum	120	15
Mode	23	3

Table 5 List of LOC and FP, and characteristics after this material was introduced

No.	LOC	FP
1	157	17
2	229	12
3	64	9
4	80	12
5	30	7
6	69	10
7	90	11
8	47	11
9	105	12
10	92	7
11	24	5
12	120	7
13	312	16
14	46	9
15	81	21
16	141	12
17	149	16
18	115	7
19	176	22
20	41	8
21	214	20
22	142	12
23	61	7
24	64	8
25	136	13
26	177	15
27	424	22
28	92	6
29	52	8
30	88	9
31	173	18
32	40	7
33	278	8
34	158	11
35	55	10
36	155	7
37	40	7
38	96	9
39	564	19
40	26	6
41	85	13
Average	129.0	11.4
Median	92	10.0
Distribution	11747.8	22.8
Range	540	17
Minimum	24	5
Maximum	564	22
Mode	64	7

Regarding median, before this material was introduced the median was 37 steps; after this material was introduced the median increased to 92 steps, two point five times more than before. As shown here, after this material was introduced a substantial increase in the number of steps occurred and this reveals the effectiveness of this material.

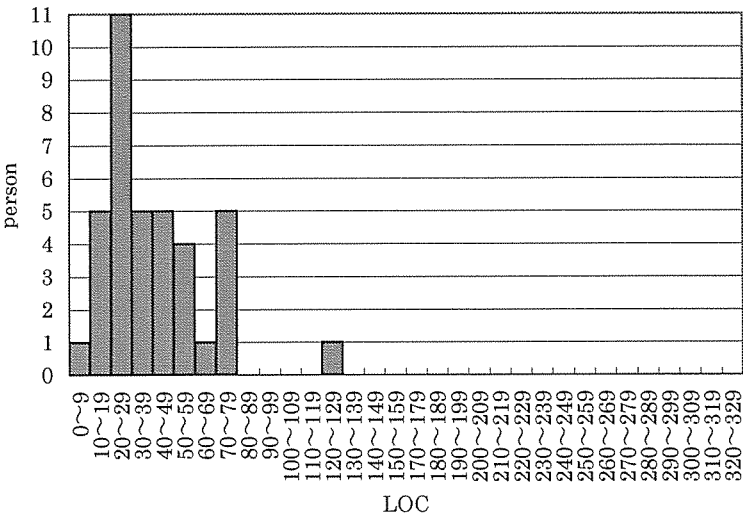


Fig. 5 Distribution of the number of source code steps before this material was introduced

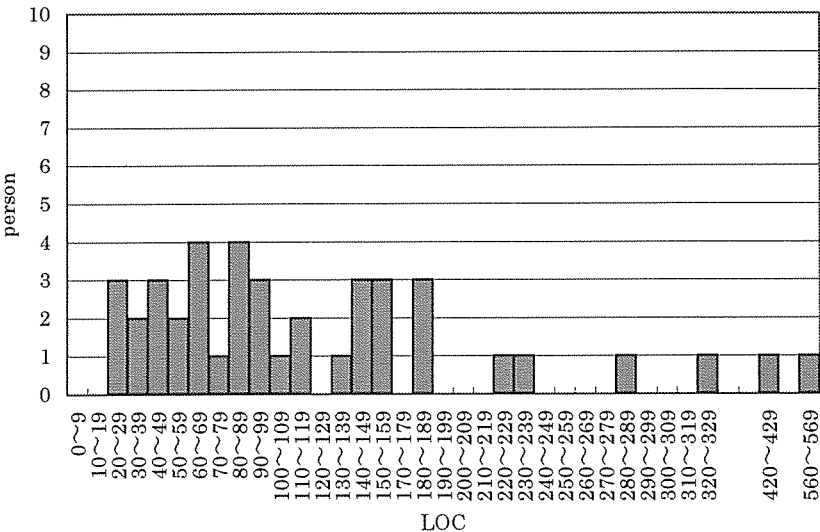


Fig. 6 Distribution of the number of source code steps after this material was introduced

(3) Comparison by function point

To measure the effectiveness of this material, we used the function points of the animation students created and compared those before and those after this material was introduced. The function point⁵⁾⁻⁸⁾ is also used as a means to measure the productivity of software development and it is defined in Table 6. We added up all the function points that were included in the animation and determined the total number of function points for the animation.

Table 4 and 5 show the number of FP (Function Point) defined in Table 6 and the characteristics obtained before and after this material was introduced. Fig. 7 and 8 show the distribution of FP for each school year.

Table 4 and Fig. 7 show that the average number of FP was 5.8, and their distribution had a relatively wide range (from minimum 2 to maximum 15). The 18% of all numbers of FP is 3 and 92.1% of all numbers of FP is less than 10. On the other hand, Table 5 and Fig. 8 show that the average number of FP after the introduction of this material was 11.4, approximately two times

Table 6 Definition of function point

Function	Description
Draw picture	One picture as a whole is counted as having one function. Background pictures are all put together and counted as one function; painting with one color is also defined as having one function.
Movement	Movement of picture (including part of picture) is defined as one function. The change of direction of motion is defined as one function.
Change of color	The change of color in background or picture is defined as one function.
Multiple of pictures	Multiple copies of the same picture are defined as one function.
Order	Pictures successively drawn are defined as one function.
Flash	Flash such as blinking star is defined as one function.
Partial change	The partial change of picture shape or partially adding picture is defined as one function.
Notes	<p>Drawing picture) The multiple placement of the same picture is defined as one function, called "multiple placement".</p> <p>Movement 1) Movement of the same picture in the same direction is defined as one function, called "multiple movements" (Ex. In case of rain, snow or shooting star movement, multiple movement = 2 functions). Regardless of source code, when the process is believed to be the same, the movements are together are defined as one function.</p> <p>Movement 2) Movement in both directions is defined as one function, called the "change of direction of motion".</p> <p>Change of color) Regardless of the number of colors involved, the change of color is defined as one function (Ex. Fire works). Each change of color in the scene is defined as one function (Ex. Morning->noon->night. Spring->summer->fall->winter).</p> <p>Others) When the random process is employed, by using functions such as random numbers, its degree is considered and simply defined as one function called "random number used" (Rain or snow gets one function point, blinking star gets one function point).</p>

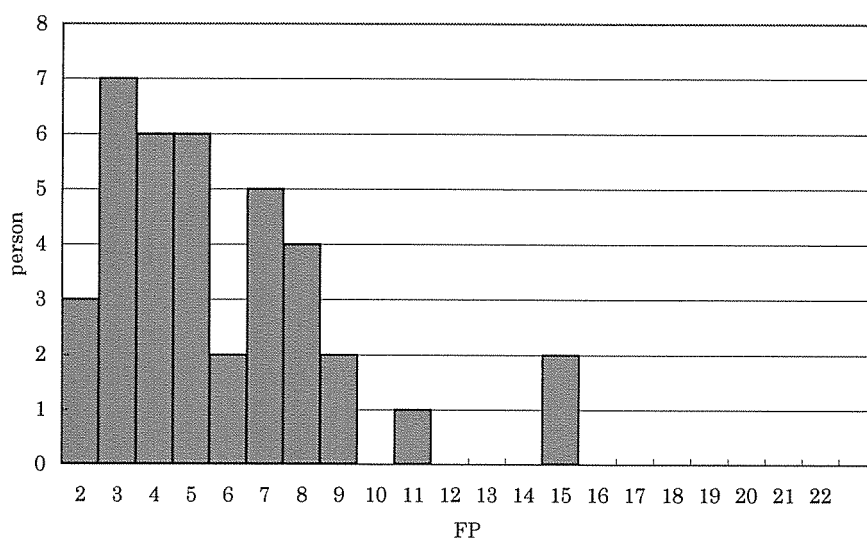


Fig. 7 FP before this material was introduced

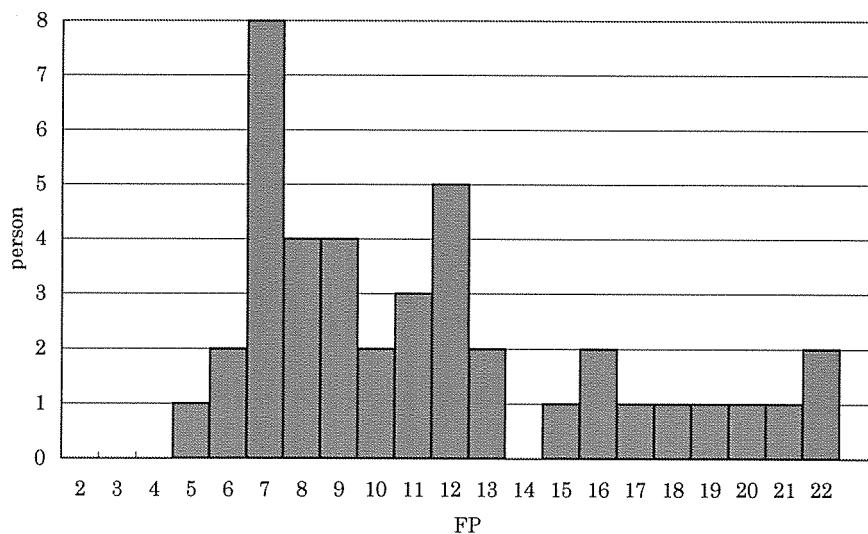


Fig. 8 FP after this material was introduced

that number before introduction, and it had a much wider range (from minimum 5 to maximum 22) with larger numbers of minimum and maximum. Overall distribution shifted towards a larger number of FP. Before introduction of this material, 92.1% had less than 10 FP numbers, while after introduction this was reduced to 46.3% with the remaining 53.6% having more than 10 FP numbers. Median was also increased to 10, which is two times that before this material was introduced. As shown here, it is clear that after introduction of this material introduction FP

greatly increased, simple animation was replaced by complex animation, and figures with multiple colors were used. It can be thought that introduction of this material helps students by allowing them to refer to this material while they are considering or creating animation, and this leads to an increase in FP of animation creation. It can be said then, in short, that this shows the effectiveness of this material.

Looking at the survey results, and a comparison of source code for animation creation, it can be said that this teaching material on the web contributes to the increase in FP and the volume of animation created.

6. Conclusion

The teaching material we have developed to help students understand difficult issues in creating animation and make up for the shortcomings of printed material has worked as it was intended and achieved substantial results. We wish to improve this material by examining how the students are using this material, so that it will be more effective in the future.

We would like to thank Ms Takahashi for her support.

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