Analyzing the Motivation Factors of the Students in the Art and Design Faculty to Learn Programming

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Abstract The purpose of this paper is to analyze the relation between the students' desire to create beautiful artwork and the motivation to learn programming when the results of programming are works of art and the students are in the art and digital design faculty. The programming environment used in this study was Processing which can produce fine artwork with relatively simple codes. The programming courses with Processing were offered at two universities, and the SIEM assessment standard with small modifications was used for evaluating the learners' motivation levels to learn programming and the levels of aesthetic appreciation of beauty.

It has been verified from the analysis of the SIEM assessment standard that the desire of the students to create aesthetically satisfying artwork is important for the motivation to learn programming. Also, we have outlined the items that affected the change of the motivation index using the statistical analysis method.

Keywords: teaching materials, Processing, computational figures, ARCS motivation model, programming education

1. Introduction

There has not been organized form of knowledge about the relation between the teaching materials of computer programming and motivation to learn, though motivation is considered to be important in programming education in which student's active participation is crucial. This paper addresses the problem of teaching introductory programming to non-computer-science students and in particular to the students in the art and digital design faculty. Educators face a lot of difficulties in motivating the non-computer-science students to learn programming because programming is not a primary interest of those students [(1)]. This problem is becoming increasingly important significant as computing and programming is spanning every technical and non-technical subject of studies.

We believe programming is very important for the students in the area of art and digital design because of the following reasons: (1) Many art and digital designers use computer applications today to create their work. Therefore, if they fully understand the mechanisms of those applications and the structures of data they use, they can improve their environments for creation and make the process more efficient [(2)]. (2) There are some artistic environments in which artwork can be directly generated by programming, such as Processing [(3)] and Design By Numbers [(4)]. Therefore, if the students studied a curriculum without programming, they would miss some important means of art creation [(1)].

The main purpose of this study is to analyze the relation between the students' desire to create aesthetically pleasing artwork and the motivation to learn programming when the results of programming are works of art and the students are in the art and digital design faculty. According to The Concise Oxford Dictionary of Current English [(5)], "beauty" means "A combination of qualities, as shape, proportion, color, in human face or form, or in other objects, that delights the sight". In this paper, however, the meaning of beauty is limited to the artistic qualities of shapes, colors, and movements on a computer screen that delights the sight. This meaning of beauty was conveyed to the students by showing some example artwork.

The relation between attitude and motivation for learning has been actively studied in psychology [(6)]. R. Pekrun, T. Goetz, and W. Titz evaluated the attitude of students toward learning, and confirmed that there were correlations between the academic emotion of students and the following: (1) achievement, (2) motivation to learn, and (3) self-regulated learning [(7)]. In the area of programming, M. Feldgen and O. Clua studied students' favorite exercises among calculus, engineering, business, and games by analyzing their homework, and verified that the students' preferred context was games [(8)]. Although many researchers have studied learners' motivation as shown above, there has not been any significant research on the motivation of students in the art-design faculty to learn programming. Therefore, we used a programming environment in which the results of programming are works of art that the students in the area of art design would feel comfortable with, and

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Table 1 Syllabus of the programming courses

Order	Title	Contents
1	Computers and Processing	hardware and software, characteristics of Processing
2	How to Use Processing	statements and comments, coordinates, basic figures, color
3	Variables	variables, arrays
4	Repetition	for sentence, nested for sentence, while sentence
5	Conditional Branch	if sentence
6	Creation of 2D Figures	creation and appreciation of 2D figures
7	3D Figures	commands for drawing 3D figures
8	Displaying Images	images, background images
9	Algorithms of Animation	the algorithm for creating moving images
10	Mouse Input	mouse click, coordinates of a mouse pointer
11	Bezier Curves	creation of artwork with Bezier curves
12	Fractal Figures	fractal figures, creation of artwork with fractal figures
13	Creation of Animations	creation of animation
14	Conclusions	concluding remarks

Table 2 Tactics used to comply with ARCS model

ARCS	Measures	Syllabus
A.1. Perceptual arousal	Aesthetical satisfaction on the resulting artwork.	1 - 13
A.2. Inquiry arousal	Asking the students to guess the codes of artwork.	6
A.3. Variability	Moving from still images to moving images, and to receiving mouse input.	1 - 13
R.1. Goal orientation	The students are in the art and digital design faculty.	1 - 13
R.2. Motive matching	Creating their own artwork in free asignments.	6, 13
R.3. Familiarity	Relating repetition and conditional branch to 2D design.	4, 5
C.1. Learning requirements	Showing examples.	1 - 13
C.2. Success opportunities	Changing some parameters can make the artwork much more attractive.	4 - 13
C.3. Personal control	The students use their own creativity to create their original artwork.	6, 13
S.1. Natural consequences	The students will be able to use the knowledge in their own work.	1 - 13
S.2. Positive consequences	Expressing appreciation of students' artwork.	4 - 13
S.3. Equity	Encouraging the students to continue learning Processing.	14

analyzed the relation between the teaching materials and the motivation of the learners.

Because of the nature of the students, a programming environment specialized for design/art called Processing was used in this study. It is an Open Source programming environment initiated by C. Reas and B. Fry [3]. With Processing, fine artwork can be created from relatively simple codes. Fig. 1 shows the window of Processing. The codes are written in the text editor area, and when the run button is pressed another window pops up to show the resulting artwork.

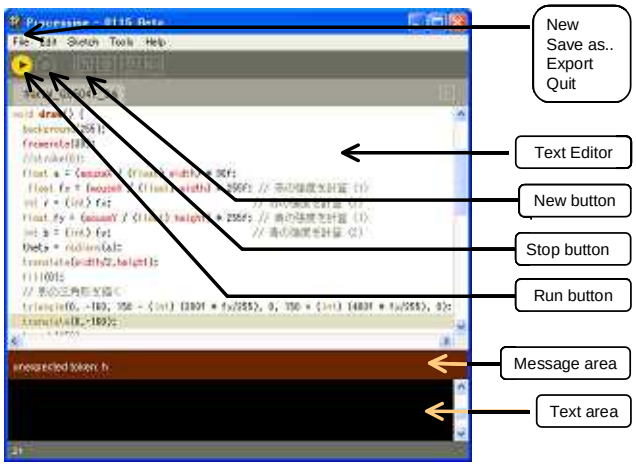

Fig. 1 The Processing programming environment

The teaching materials were designed in accordance with the ARCS motivation model [9] as much as possible so that the students would be adequately motivated. The programming courses with Processing were offered in two universities (university A in Japan and university B in Taiwan). In this paper, we paid attention to the data of university A, and compared the data of university A with that of university B in order to extract the characteristics of university A. The motivation levels of the students were measured using the SIEM assessment standard introduced by S. Dohi, O. Miyakawa ,and N. Konno [10], and the relation between the teaching materials and motivation was derived from the results of the measurements.

2. The Teaching Materials and Motivation

2.1. The Programming Courses

In university A, six among the 14 classes of the "Introduction to Information Technology" course were used to teach programming. The class met once a week, and the duration of each class was 90 minutes. Therefore, nine hours in total was used for teaching programming. There were 84 second-year students in the class and all of them were from the art design faculty (character design). In university B, programming was taught in the "Computational Figures and

Table 3 SIEM assessment standard with added evaluation items

Factor 1: Class construction factor	
(1) Success opportunity	Do you think you have gained a sense of accomplishment by leaning and comprehending classroom instruction?
(2) Familiarity	Do you think that the course contains user-friendly contents?
(3) Pleasure	Do you think this programming class is enjoyable?
(4) Comprehension	Do you think that the programming course is easy to comprehend?
(5) Perceptual arousal	Do you think it's fun to see how the program you design and input works?
(6) Significance	Do you think the purpose and the significance of the course is clear?
(7) Curiosity arousal	Do you think your curiosity is aroused in class?
Factor 2: Spontaneity factor	
(8) Future usefulness	Do you think that the knowledge learned in this class will be useful in the future?
(9) Improvement effort	Do you think you want to study more about computer programming?
(10) Self control	Do you think you want to study in your own unique way by utilizing the knowledge gained in your classes?
(11) Self goal	Do you think that the learning goal which you should attain is clear?
Factor 3: Interaction factor	
(12) Communication	Do you think you communicate well with your teacher and fellow students?
(13) Positive consequence	Do you think that teachers and fellow students are friendly to you?
(14) Equity	Do you think the assignment corresponds with the course contents?
Factor 4: Attendance factor	
(15)Attendance enthusiasm	Do you think your class motivates you enough not be absent?
(16) Activation Scale	Do you think you are active in class?
MV evaluation items	
(17) Importance	Do you think studying computer programming is crucial?
(18) State recognition	Do you think you have acquired enough computer knowledge and skills?
(19) Expectation	Do you think you would like to gain more computer knowledge and skills?
Evaluation items about Processing	
(20) Perceptual arousal	Do you think it's fun to see the results of Processing programming?
(21) Improvement effort	Do you think you want to strive to create more beautiful artwork with Processing?

Animation Processing" course. This was an intensive lecture and it took four days: three hours on the first day, three hours on the second day, six hours on the third day, and six hours on the fourth day. Therefore, 18 hours in total was used for the course. The duration of one class was 50 minutes. There were 53 students in the class, and they were all from the digital design department (Information Communication, Visual Communication Design, Multimedia and Entertainment Science, and Graduate School of Digital Content and Animation). There were all year levels of students, from first-year to graduate school, mixed in the class. The common syllabus for the two courses is shown in Table 1.

2.2. The Teaching Materials

As shown in Table 1, the course contained 14 topics (not in the same duration). The course started with an introduction to computers and an introduction to Processing, and then moved on to how to use the Processing programming environment. It was followed by the basics of programming, such as variables, repetition, and conditional branches. In topic 6 (Creation of 2D Figures), the first free-design assignment was given to the students, and they designed artwork without animation effects. After that, 3D figures were briefly introduced, and the ways to display images were taught. The ways to make animation and the ways to make the students' artwork interactive with mouse input were taught next. In topic 11 and 12, the functions to generate Bezier curves and Fractal trees were taught so that the students could make attractive animation. In topic 13 (Creation of Animation), the second free design assignment was given to the students, and they designed artwork with animation. The course was summarized in the last class.

The teaching materials used in this study were designed in accordance with the ARCS motivation model introduced by J. M. Keller [(9)]. It is an educational theory that describes the factors of the motivation to learn. Table 2 shows the tactics used to comply with the ARCS model and the topic numbers in the syllabus in which the measures were used.

3. The Assessment Standard and the Analysis Method

3.1. The Assessment Standard

For measuring students' motivation levels, the SIEM assessment standard [(10)] was used. The SIEM assessment standard is a metric that can be used to objectively measure students' motivation levels to learn programming. When using this standard, the questionnaires that contain some evaluation items are supposed to be filled out by the students frequently. There are in total nineteen evaluation items in the standard, and many of them are related to the sub-factors of the ARCS model [(9)]. Each item is presented using a five-point Likert Scale where answer 5 always

Table 4 MV of the students in the two universities

	Institute	university A			university B		
	Measurement Period	Early	Middle	Latter	First	Second	Latter
Total	Mean	17.1	13.9	12.7	17.0	17.7	18.9
	Maximum	25	25	25	25	25	25
	Minimum	6	1	1	8	8	9
	Variance	25.0	37.0	31.7	18.4	23.2	23.5
	Total	484	391	357	611	638	679
High group	Ratio	37.9%	10.3%	10.3%	38.9%	47.2%	50.0%
20 <= MV	MV mean	21.8	25.0	23.3	21.4	22.1	23.1
Medium group	Ratio	51.7%	62.1%	48.3%	52.8%	50.0%	47.2%
10 <= MV < 20	MV mean	14.7	15.1	14.2	14.4	14.2	15.0
Low group	Ratio	10.3%	27.6%	41.4%	8.3%	2.8%	2.8%
MV < 10	MV mean	8.0	5.6	7.3	8.0	8.0	9.0

corresponds to an agree and answer 1 to a disagree. In this study, we added two more evaluation items which are related to the artwork generated by Processing. Since these items refer to the specific situation where the outcomes of the programming give aesthetical satisfaction to the students, these items will give us more precise measure than the generalized items. The evaluation items of the SIEM assessment standard are shown in Table 3. In this table, the first nineteen items are grouped into four factors which had been derived from a factor analysis [10]. Item (20) and item (21) are special for this research. Item (20) is similar to item (5), but its question is more specific and related to the results of Processing programming instead of general programming. Item (21) is similar to item (9), but its question is more specific to Processing and is particularly related to the desire to create more beautiful artwork.

Although all of the items are used for evaluating students' motivation levels, there are two particular items, (17) and (19), which are used to calculate the motivation index (abbreviated as "MV" in this paper). MV is calculated as equation (1) [10].

$$MV = (17)\ \text{Importance} \times (19)\ \text{Expectation} \quad \cdots\cdots (1)$$

Therefore, the possible range of MV is between 1 (minimum) and 25 (maximum).

In both universities, the time series evaluation of motivation using the questionnaires with SIEM assessment standard was conducted three times in all: early in the course, halfway through, and late in the course. At university A, the evaluation was conducted after topic 4, after topic 6, and after topic 11. At university B, it was conducted after topic 6, after topic 11, and after topic 14.

3.2. The Analysis Method

Our analysis process of the data obtained in the SIEM assessment standard has three parts P1, P2, and P2, where "P" stands for "Phase", and they are shown below.

(P1) The basic statistics (mean, maximum, minimum, variance, etc.) of the SIEM assessment standard are calculated and analyzed.

(P2) The factors in Table 3 that affected the change in MV are extracted, and are compared with the Processing evaluation items.

(P2.1) The t-test between the same evaluation items at different times (between early and middle, or between middle and latter), are conducted, and the factors in which the majority of items show statistical significance between two different phases are extracted. Since these factors had changed from the previous condition, these

Table 5 t-test between the same evaluation items at different times

Univ.	Between	Factor 1							Factor 2			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
A	Early and Middle	0.02	0.06	0.01	0.00	0.18	0.05	0.01	0.00	0.00	0.01	0.66
	Middle and Latter	0.49	0.60	0.61	0.77	0.41	0.57	1.00	0.86	0.17	0.87	0.92
B	Early and Middle	0.49	0.66	0.83	0.15	0.82	0.80	0.62	0.70	0.30	0.21	0.05
	Middle and Latter	0.32	0.01	0.09	0.15	0.05	0.04	0.03	0.21	0.34	0.13	0.64

Univ.	Between	Factor 3			Factor 4		MV evaluation items			Processing	
		(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
A	Early and Middle	0.64	0.56	0.25	0.01	0.26	0.00	0.26	0.00	0.06	0.00
	Middle and Latter	0.86	0.60	0.85	1.00	0.74	0.63	0.46	0.39	0.27	0.71
B	Early and Middle	0.47	1.00	0.74	0.28	0.29	0.05	0.10	0.80	0.06	0.64
	Middle and Latter	0.00	0.10	0.42	1.00	0.21	0.25	0.47	0.10	0.77	0.77

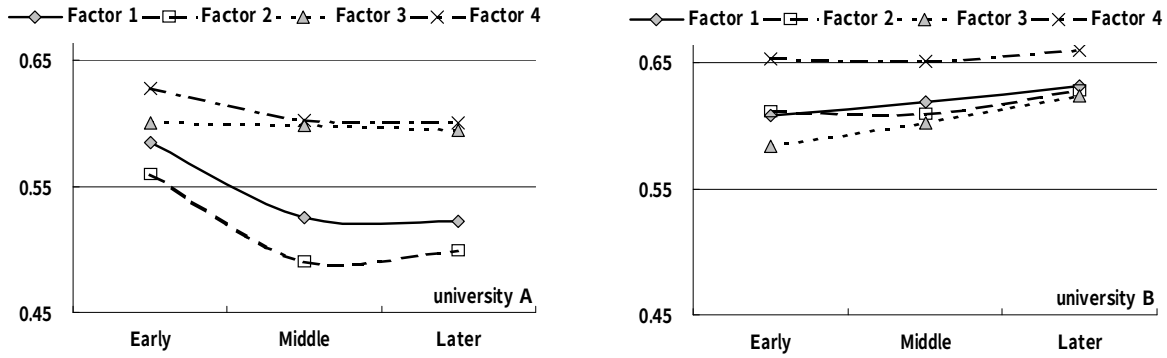

Fig. 2 The change of the mean (converted into logarithm) of each factor

Table 6 The means of factor 1, factor 2, and Processing evaluation items

Univ.	Measurement period	Average of factor 1	Average of factor 2	Processing	
				(20)	(21)
A	Early	3.84	3.63	4.36	4.07
	Middle	3.35	3.09	4.00	3.54
	Latter	3.33	3.15	3.71	3.64
B	Early	4.06	3.94	4.19	4.14
	Middle	4.12	4.00	4.44	4.19
	Latter	4.29	4.15	4.42	4.22

factors are considered to have affected the change of MV.

(P2.2) Comparing the means of the items in the factors extracted in (P2.1) and those of the Processing evaluation items, (20) and (21).

(P3) The correlation coefficients between the items in the factors extracted in (P2) and the MV evaluation items are calculated. The correlation coefficients greater than 0.7 are considered to be showing strong correlation [11].

In (P1), the tendency of the learners as a group is analyzed. In (P2), the Processing evaluation items are compared with the factors that affected the change in the motivation levels. In (P3), the items that affected the motivation levels are extracted.

4. Analysis

Using the SIEM assessment standard and the analysis method mentioned in section 3, the motivation of the students to learn programming was analyzed. The number of valid samples (the number of students who filled out all three questionnaires) was 29 in university A and 36 in university B. Table 4 shows the values of MV measured at different times according to the analysis method (P1). Although MV taken early in the course at university A (17.1) was higher than that of university B (17.0), MV became much higher at university B when it was taken late in the course. At university A, the time series evaluation of MV shows a decreasing tendency, while at university B, it shows an increasing tendency. A similar decreasing tendency of MV was reported in reference [10]. Since the teaching materials of programming become more difficult as time progresses, it is understandable to have a decreasing tendency of MV. It is rather astonishing to see the increasing tendency of MV at university B.

The change of mean of each factor is shown in Fig. 2. For this figure, the means were processed with logarithm in order to adjust the differences of the learning environments of the two universities. Although we have dealt with both university A and university B in this paper, we will pay attention to university A in this section, because we will be able to advance and increase efficiency of the programming education in the art and digital design faculty using the result of this paper if we deal with nearby universities in our country. Since the means of all the four factors seem to have decreased in university A, further analysis was conducted using the analysis method (P2). The results of the t-test between the same evaluation items at different times are shown in Table 5. In this table, the gray cells contain the p-values less than or equal to the threshold chosen for statistical significance (0.05 level). According to this table, five out of the seven items in Factor 1 taken in the middle of the course at university A are distinct from the same items taken early in the course, and the same thing can be said for three out of the four items in Factor 2 for university A. Therefore it is assumed that the two factors had the primary influence on the decrease of MV at university A.

In order to analyze the influence of the aesthetical interest of the students on MV, the means of Processing evaluation items are compared with the means of the two factors (Factor 1 and Factor 2). Although item 20 asks about fun,

Table 7 Correlation levels

Univ.	Measurement period	Item	Factor 1							Factor 2			
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
A	Early	(17)	0.12	0.36	0.52	0.58	0.52	0.31	0.46	0.28	0.43	0.39	0.39
		(19)	0.38	0.25	0.52	0.56	0.55	0.33	0.44	0.51	0.72	0.64	0.34
	Middle	(17)	0.67	0.66	0.59	0.46	0.58	0.51	0.67	0.72	0.75	0.71	0.50
		(19)	0.77	0.74	0.66	0.62	0.55	0.68	0.77	0.67	0.77	0.77	0.47
	Latter	(17)	0.52	0.44	0.53	0.43	0.54	0.65	0.64	0.64	0.72	0.66	0.58
		(19)	0.43	0.37	0.66	0.45	0.67	0.53	0.83	0.43	0.75	0.75	0.59

we consider this item to be related to the aesthetical interest of the students because when one feels fun to see the artwork generated by Processing, he/she is aesthetically satisfied. These means are shown in Table 6. According to this table, the means of Processing evaluation items are greater than those of the items in Factor 1 and Factor 2. This fact suggests that the aesthetical interest affects MV more than these two factors.

In order to analyze the reason why MV at university A decreased, the analysis method (P3) was used, and the correlation between the two MV evaluation items, (17) and (19), and the items in Factor 1 and Factor 2 were calculated. These correlation coefficients for university A are shown in Table 7. In this table, the gray cells contain the correlation coefficients that are greater than or equal to 0.7. According to Table 7, the evaluation items (9) and (10) have the largest number of significant correlations with the MV evaluation items, and therefore seem to have stronger influence on the change of MV than the other items. Also, the evaluation item (7) has correlation with one of the MV evaluation items (item (19)) for Middle and Latter.

5. Discussion

In the two universities, the means of the Processing evaluation items were greater than the means of the items in the factors that significantly changed from early to middle in the class. Therefore, it has been verified that the students' desire to create aesthetically satisfying artwork is important for the students in the art and digital design faculty to learn programming.

In the analysis of the correlation coefficients for Factor 1 and Factor 2, items (9), (10), and (7) seem to have significant influence on the decrease of MV. Therefore, if item (9) *Improvement effort*, item (10) *Self control*, and (7) *Curiosity arousal* are improved, that would help us prevent the decrease of MV. Also, we could confirm that spontaneity is important for the programming education in the art department.

Although it is common to have a decreasing tendency of MV as the learning progresses, MV actually increased slightly at university B. The reason seems to be that the students at university B could concentrate on their study because it was an intensive course taught by teachers from abroad. This is a speculation which will be further investigated in a future study.

6. Conclusions

We analyzed the relation between the teaching materials and motivation to learn programming when the result of programming was artwork and the students are in the art and digital design faculty. The programming environment used was Processing, and the teaching materials were designed in accordance with the ARCS motivation model as much as possible so that the students were adequately motivated to learn. The programming courses with Processing were offered at two universities (A and B), and the SIEM assessment standard was used to evaluate the students' motivation levels to learn programming.

In the time series analysis of motivation, it was found that MV decreased in university A while it increased slightly in university B. The decrease of MV in university A was mainly affected by Factor 1 and Factor 2. Also, it has been verified that the students' desire to create aesthetically satisfying artwork is important for the students in the art and digital design faculty to learn programming. The evaluation item (9) *Improvement effort* and item (10) *Self control* have strong correlation with the MV evaluation items for university A, and therefore seem to have stronger influence on the decrease of MV than the other items.

We could also quantitatively analyze the learning tendency of the students in the art departments when learning programming. We think that we will be able to use the knowledge obtained from the analysis to effectively improve the programming education in the art departments, which has been relying on teachers' experience. We expect that this study will advance the programming education in the art departments. Also, the result of the analysis in this study is considered to be useful for constructing e-learning systems for the students in the art and design faculty because the assessment standard used in this analysis is based on the ARCS model which is often used in the courseware design.

There are some other methods of motivating students to learn computer programming, such as using robots and games, to which we have not compared our method. Therefore, we plan to analyze in what cases our method would be superior to other methods.

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