A Drawing Learning Support System with Auto-evaluating Function Based on the Drawing Process Model

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Abstract. The purpose of this study is to develop a drawing learning support system using a networked environment. In this paper, first, we show the outline of the online drawing learning support system. Second, we describe the drawing process model that support individual drawing learning. Finally, we show three examples of learning with our system.

Keywords: Drawing , Learning Support System, Drawing Process Model.

1 Introduction

Art education in a networked environment has been introduced recently. However, there are some limitations in the functions and content of tools for basic skill learning such as drawing, painting, and sculpturing [1]-[3]. Drawing is one of the fundamental skills in art education. All beginners must acquire these kinds of skills first [4],. Learning related to art requires repeated practice with a trial-and-error process [5],[6]. Therefore, to learn drawing is categorized as skill-learning [7]. In this type of learning, novices cannot recognize whether or not they draw correctly and appropriately.

The purpose of this study is to explore a support system for beginners in drawing. In this paper, we show learning flows in our system, then we describe some examples of learning with our system.

2 Online Drawing Learning Support

2.1 Learning Flows

In this study, the learner's drawing process that is recorded by a digital pen is reused in order to replay learner's drawing process [8]. A learning activity is started after the tutor defines a learning task in the learning management system (LMS). The following flows are ideal learning processes in our learning environment shown in Fig. 1:

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1. A learner draws his/her work.
2. Both of the learner's drawing process data and his/her work are registered in the LMS.

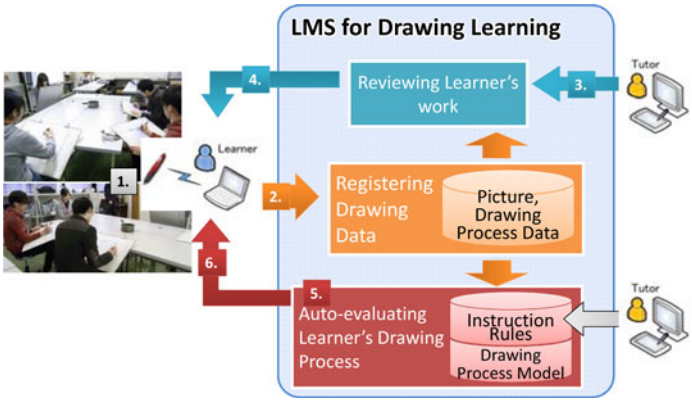

Fig. 1. Learning flows with the proposed system

[Interaction with Learner and Tutor via System]

3. A tutor evaluates the learner's work by replaying the learner's drawing process, then the tutor gives some advice on both the learner's drawing process and his/her work.
4. The learner takes the tutor's comments about his/her own drawing process and work.

[Interaction with Learner and System]

5. The LMS diagnoses the learner's drawing process based on the drawing process model (DPM) and the instructional rules that are defined by tutors.
6. The learner is given an auto-evaluated result from the diagnosis.

2.2 The Drawing Process Model

Our system arranges the learners' drawing processes by using the drawing process model (DPM). The DPM is developed by an inference engine that is able to detect three drawing phases. This model consists of 3 types of parameters. They are the drawing step, the drawing phase and the features of the drawing strokes. Fig. 2 shows an outline of the DPM.

Seven Drawing Steps. In an interview with five art experts, we collected the drawing processes of experts. Then, we formulated the seven step model as a hypothesis for simplification of an artist's drawing process. The contents of each step are shown in the lower part of Fig.2.

"Drawing is seeing"[9]. Hence, the first step is to carefully observe the drawing subject. The relationship between the light source and the drawing objects is also checked in this step. In step 2, the relative locations of the objects are confirmed based on the vanishing points. In the next step, the composition of this picture is

defined. The drawing area is fixed on the drawing paper. In step 4, the outlines of the drawing subject are expressed in simple lines in a balanced way. The rectangle, the oval, triangle, straight line, and simple curve are used consciously in this step. The size, the location, and the direction of each object are also pictured in this step. In step 5, shading is added. Various values of light and dark are expressed in the drawing. The shading techniques become complex for a square pillar, a cylinder, and a sphere in this order. Shading should be added first to objects whose outline shapes are square pillars, second to cylinder shapes and then finally to spheres. In step 6, a learner checks the material of each object, and then expresses its texture in the drawing. Finally, the finishing touches are added. A learner draws details of each object. The balance of the total subject is also considered in this step.

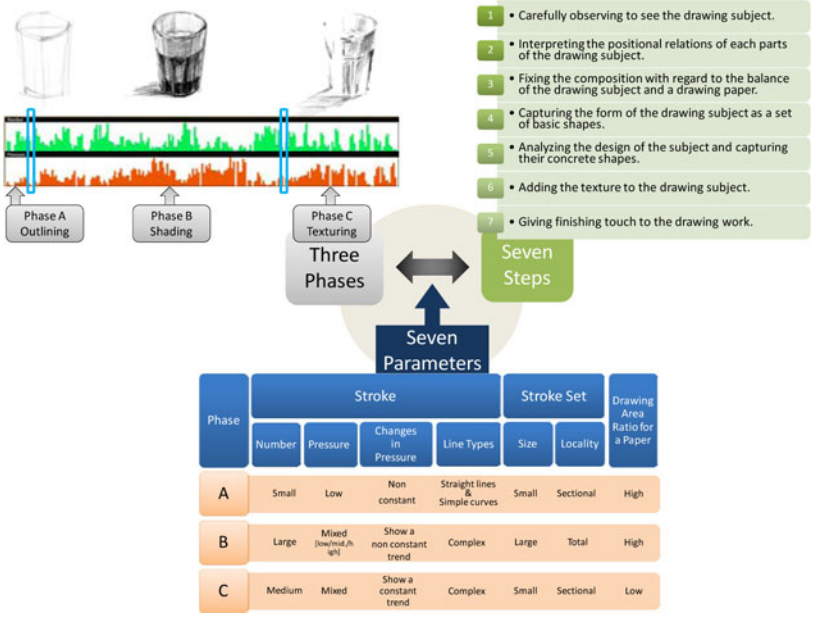

Fig. 2. The drawing process model

Three Drawing Phases. We found three different drawing phases from quantitative investigations of the time variation in the drawing strokes and the pen pressures of a digital pen used by art experts. The left side of Fig. 2 shows the features of strokes and pen-pressures of the drawing process. The features of each phase can be described as follows:

- Phase A [Outlining]: A learner interprets the drawing composition and the outline of the whole object by using simple lines to define the proportion in a perspective way.
- Phase B [Shading]: A learner draws the drawing subject totally and adds shade for whole parts.

- Phase C [Texturing]: A learner adds the texture of the subject in detail. He/she fixes the balance of the subject on the drawing paper.

The boundary of each phase in the drawing process is determined mainly based on the changes in pressure. In this study, the state of the pressure changes in writing a stroke of a drawing is called "changes in pressure". In an ideal drawing process, the artist outlines the motif in the first stage of his/her drawing (see Step 3 in drawing steps). At this stage, an ideal artist draws a rough line using low pen pressure, and draws the outline of motif using a high pressure line. Therefore, the pressure at this stage tends to be lower, and the state of change is not constant. So, the drawing section which satisfies the following three conditions is identified as Phase-A.

– There are multiple sections where the average pressure is zero or close to zero.
– The state of pressure change does not tend to be constant.
– The ratio of the area of the drawing in that section to the area of the final draw is more than 75%.

The process parts for Phase-B and Phase-C are selected from the whole drawing process other than the section which is assigned to Phase-A. At first, our system divides the selected parts into 10 blocks in the same time span. In each block, if its state of pressure change does not show a constant tend, the block is assigned to Phase-B. Also, if it shows a constant trend, the block is assigned to Phase-C. Then, the sequential blocks in the same phase are grouped. Two division lines that are detected by these rules are shown in the squared areas in the left part of Fig.2.

Seven Parameters for Drawing Stroke Features. We have to define concrete and objective features of each phase in order to define these three phases of the drawing process. The left part of Fig.2 shows the quantitative features of these phases. Seven parameters are shown in this table. They are the number of strokes, the stroke pressure, the changes in pressure, the line types, the degree of assembled stroke size, the dispersion of the drawing area, and the ratio of the drawing area. The number of strokes and the pen pressure are relative values in the drawing process. The size and the dispersion of the stroke sets are relative values on the drawing paper (or entire drawing area)

Each parameter is expressed in more than two levels. The number of strokes is expressed as small, medium, or large. The pen pressure is expressed as low, medium, or high. The changes in pressure are expressed as non constant or constant. The line types are point, straight-line, simple curve, or complex line (includes curve). The size of the stroke sets is large or small. The locality of the stroke sets is sectional or total. The ratio of the drawing area is high or low.

2.3 Drawing Evaluation with the DPM

Fig. 3 shows a drawing process viewer that our system provides. The upper part of this viewer is an area for replaying the drawing process and showing the instructional information. Two types of advice are added in this drawing. These are an instructional comment and an instructional drawing. The former is shown in the timeline bar in the viewer. A comment is linked to a specific point in time when the learner performs an inadequate drawing action. The latter is also connected to a point in time. In this case,

an instructor adds red lines to point out error cpositions, and adds the comment "represent the outline of the vase". The lower part is a graph area. This area includes six graphs that indicate the seven features of the drawing process. They are the number of strokes, the pen pressure, the line types, the size of stroke sets, and the drawing locality and ratio of drawing area.

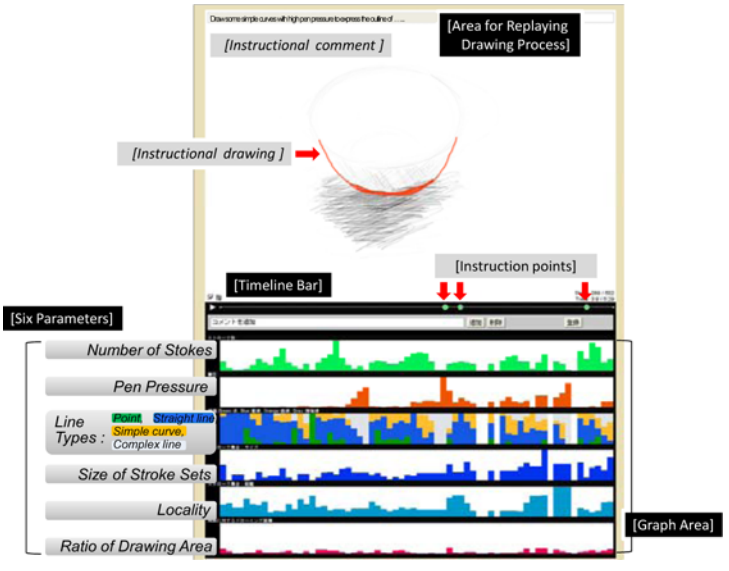

Fig. 3. An example of the drawing process viewer

The red arrow on the far left shows the first instructional comment for this drawing. Learners obtained the following advice from our system: "Draw some simple curves with high pen pressure to express the outline of the subject. Observe the drawing objects more carefully. Capture each object as a simple configuration."

3 DPM-Based Drawing Learning

3.1 Classroom Learning Support

Fig. 4 shows the drawing learning support functions of our system. Learners upload their drawing process data to our system after their drawing. The tutor of this class and all of the class members are able to access the portfolio pages for today's results (Fig. 4 upper left). A member of this class is able to refer to the drawing pictures and these process data in this portfolio. A drawing process viewer page is shown to him/her when a learner chooses a learner's drawing result (Fig. 4 upper right). A learner can replay the drawing process from anytime. This viewer is able to show graphical evaluation results for six parameters in time series graphs.

Our system generates some advice for the drawing process based on these results. The tutor's comments are also confirmed on this page. The evaluation results from

both the system and the tutor are added to the time series. The learner can recognize which points are wrong and correct the drawing.

Referring to experts' and others' drawing processes helps a learner understand the advice from the system and the tutor. Moreover, comparing one's drawing process with others could help them find new techniques and/or drawing methods. Learners hand in their drawing processes and then obtain the tutors' feedback as individual learning support tools (Fig. 4 lower part).

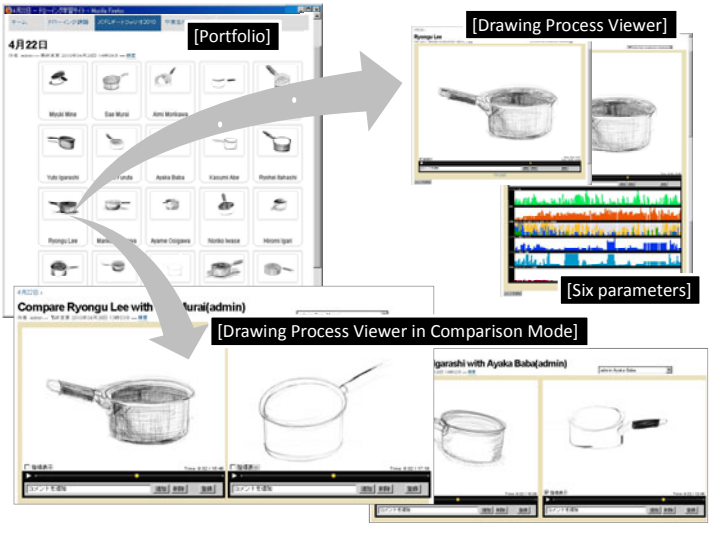

Fig. 4. The drawing learning support functions

3.2 Individual Learning Support

Overview. This function is used the between the time when a learner finishes his/her drawing and the time when a teacher gives this learner some direct instructions. To support the individual drawing learning, learners' drawing processes are analyzed based on the DPM. At first, our system separates the learner's drawing process into three drawing phases. Then, the geometrical features of each phase are compared with the DMP. Based on this analysis, our system generates advice for that learner. Timing and content of that advice are determined. There are two types of advice: instructional comments with short sentences and the instructional drawings as models.

Supporting functions. The supporting functions for individual drawing learning are as follows:

- Replaying one's own drawing process.
- Synchronous replaying of one's own drawing process with those of other learners / art experts / instructors.
- Showing the location of the 3 drawing phases in a learner's drawing process.
- Total advice comments for the whole drawing work.
- Instructional comments and drawing for a sectional drawing.

- Introduction to some drawing techniques and exercises which should be mastered by this learner.
- Introduction to the drawing work of other learners / art experts / instructors as a model.

Educational Effectiveness. The educational effectiveness of those functions was examined at an art school. The subjects were 18 students who had been at the school for 1 month. The knowledge and experience about drawing for each student was different. From the preliminary survey, we found that the 15 students were beginners. The subjects were asked to use our tool for a month for their individual learning. The frequency of use was not specifically mentioned.

In this experiment, we focus on the appearance of Phase-A in the learners' drawing processes. Phase-A is the most important part to sketch a motif. However, many instructors in art school do not tend to teach this matter explicitly to their learners. Before this experiment, Phase-A appeared in the drawing processes of 3 students who were not novices. The drawing processes of the other 15 students, by contrast, did not show Phase-A. The works in Fig. 5 are the final drawings of two students whose drawing process does not have Phase-A. Fig. 6 and Fig.7 show the drawing results in each phase of these students. The upper part of each figure shows a graph of the changes in pressure in a time-line and the detected phases. The lower part shows drawing results in each phase. In those results, two problems can be point out.

- Learners wrote some clear lines with high pressure from the beginning.
- Learners did not draw the whole shape of the motif at the beginning.
  Thus, this learner was trying to show the form of a motif immediately.

During the experiment, our system checked for the appearance of Phase-A. If Phase-A did not appear, some text comments (for example "You should learn the. techniques so as to form a composition by drawing a simple shape.") are given to the learner at an appropriate time. The system also introduces a link to the related exercises. In these exercises, a learner is asked to draw some lines with the indicated pen pressure, and/or to draw the whole outline of the motif with low pressure. At the same time, the system suggests to refer to an expert's drawing process to form the composition in simple shapes.

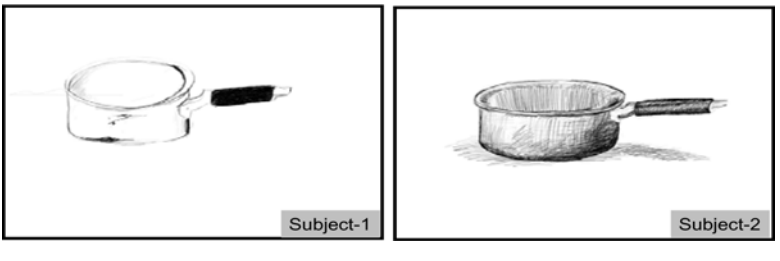

Fig. 5. The final works prior to the experiment

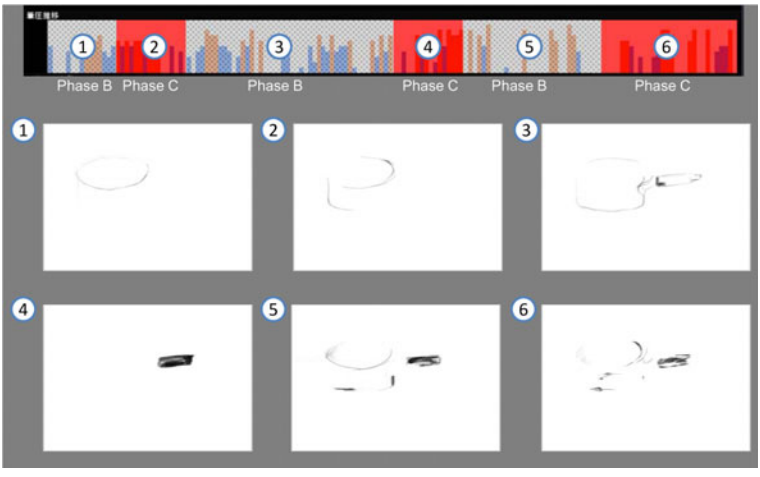

Fig. 6. The drawing results in each phase prior to the experiment [Subject-1]

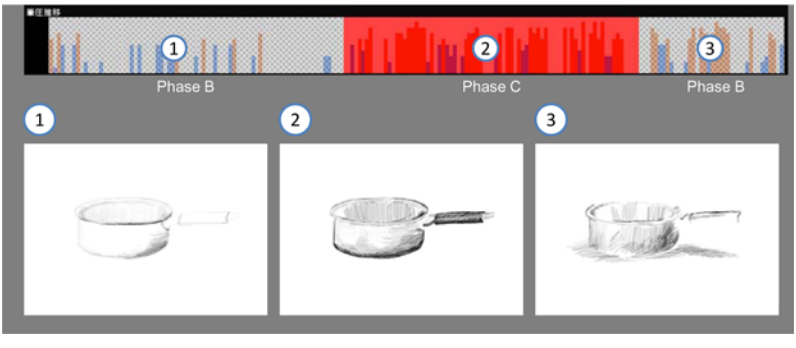

Fig. 7. The drawing results in each phase prior to the experiment [Subject-2]

After the 1 month experiment, in 6 out of 15 students whose drawing process did not include Phase-A, a section of Phase-A began to appear in their work. These students certainly used our system in their individual learning. The other 9 students could not draw an outline of the motif at the beginning of their drawing yet. The frequencies of use of our system were lower than the students who were able to improve their drawing. Fig. 8 shows the final works after the experiment. Fig. 9 and Fig.10 show the drawing results of each phase for two students (the same students as Fig. 6 and Fig. 7). The qualities of the final works are not high (almost the same level as 1 month before), but in these results, learners try to make the outline of the motif using low pressure at the beginning of their drawing. The following comments were collected from the subjects after the experiment.

- I can replay my own drawing process by using this tool, so I can carefully and repeatedly check my bad habits.
- I can view and replay the drawing processes of others, so I can better understand the necessary techniques.

– The timing of advice and the timing of bad drawing is synchronized, so I can easily recognize my drawing points which need amendment.

From these results, we can see the potential for educational effectiveness of the DPM based individual drawing learning support.

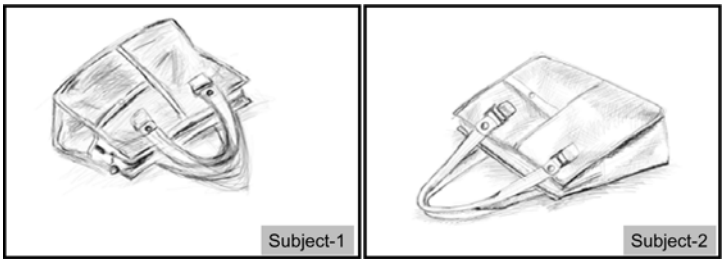

Fig. 8. The final works after the experiment

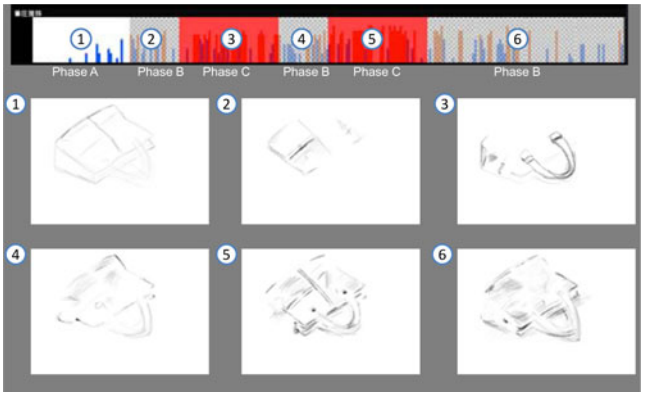

Fig. 9. The drawing results at each phase after the experiment [Subject-1]

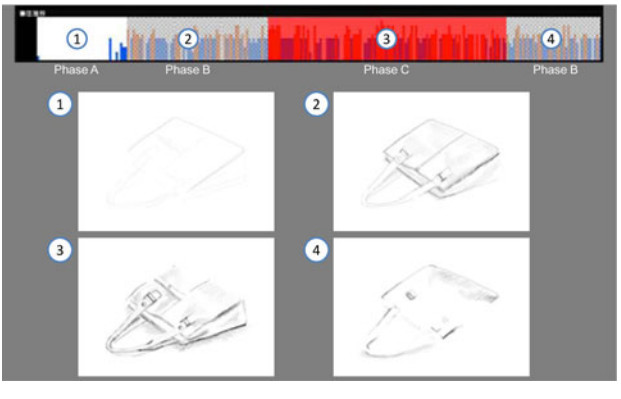

Fig. 10. The drawing results at each phase after the experiment [Subject-2]

4 Conclusion

In this paper, we describe the overview of our drawing support system in a networked environment, then the concept and the functions of the DPM are shown. Its application to classroom learning and individual learning are also considered. Finally, the educational effectiveness of our system is examined. From an experiment with students in an art school, we can see that our drawing learning support system is useful if the users are limited to beginners of drawing.

In future work, we will find adequate drawing tasks to suit constraints and limitations of the digital pen. During the operation of this system in practice, we try to arrange and revise the DPM and formalize more instructional rules for drawing learners.

References

1. Tweddle, L.K.: Reinventing Papert's Constructionism - Boosting Young Children's Writing Skills with e-Learning Designed for Dyslexics. The Electronic J. of e-Learning 6(3), 227–234 (2008)
2. Univ. of the Arts London: MA Visual Arts (Digital Arts Online), http://www.wimbledon.arts.ac.uk/ (accessed February 28, 2011)
3. Open Dictionaly: Arts; VisualAtrs; Drawing; Education, http://www.dmoz.org/Arts/Visual_Arts/Drawing/Education/ (accessed May 16, 2010)
4. Sekine, E.: A Trial to develop the ART SYSTEM. Art Education 6, 89–100 (1984) (in Japanese)
5. Bernstein, N.: The Co-ordination and Regulation of Movements. Pergamon Press, NY (1967)
6. Latash, M.L.: Progress in Motor Control. Bernstein's Traditions in Movement Studies, vol. 1. Human Kinetics, Urbana (1998)
7. Furukawa, K.: Skill Science. J. of JSAI 19(3), 355–364 (2004) (in Japanese)
8. Nagai, T., Kayama, M., Itoh, K.: A basic study on a drawing-learning support system in the networked environment. In: Jacko, J.A. (ed.) HCI International 2009. LNCS, vol. 5611, pp. 860–868. Springer, Heidelberg (2009)
9. Ernest, W.W.: The Art of Pencil Drawing, Watson-Guptill, NY (1985)