A Learning Method for Product Analysis in Product Design

Learning Method of Product Analysis Utilizing Collaborative Learning and a List of Analysis Items

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Abstract. Product design is an essential market research method for design planning. In this study, we propose a learning method for product analysis by combining collaborative learning and a list of analysis items by a learner who aims to become a professional designer. This proposal had the following features: (1) facilitation of multi-perspective analysis (even for beginners) based on a list of analysis items and (2) facilitation of objective analysis through the introduction of collaborative learning. In addition, we conducted two experiments to verify the effectiveness of the proposed method. As a result, the following learning effects were verified: (1) even a beginner can conduct a multi- perspective analysis and recognize improvement in analytical skills, (2) product analysis clarifies the direction for product improvement once the purpose of the product is understood, and (3) product analysis could be useful for discovering problems with the product.

Keywords: product design, product analysis, collaborative learning, list of analysis items.

1 Introduction

In recent years, the importance of user-centered design has been growing in the product design process. Therefore, the design plan stage, where a user's needs are grasped, has becomes vital. The design plan includes information gathering, product evaluation, and consideration of product image. In product evaluation, the acknowledgment, attributes, and operability of the product are evaluated (Wakayama University, 2000). According to our investigation concerning a company's design capability, it is obvious that the ability to analyze and evaluate a product is a design capability that professional designers expect (Lin, Kato, 2010). Current design styles can be understood by analyzing products. In addition, the features of a product can be

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obtained from the materials, fabrication technology, and other factors surrounding the product (Bruno, 2007). The technique and viewpoint of product analysis must change depending on the object of the analysis and its purpose. Therefore, the analysis quality also changes. An idea with business validity based on market needs is important for novice designers. Therefore, observation and analysis of the correct product are necessary. This research applies to product analysis in which the advantages and disadvantages of the product can be grasped, and through which the designer can understand a product from various perspectives.

Such product analyses use Yamaoka's 70 design items that support observation of the product (Yamaoka, 1998), and Bruno's analysis items that support product analysis (Bruno, 2007). The 70 design items that Yamaoka proposed are classified in 8 large categories according to the purpose of the observation. These analysis items are comprehensive, multilateral, and useful to a designer for practical purposes, but they are unpractical for the education of a beginner, because they are specialized and lengthy. On the other hand, Bruno suggests a list of 24 items, which are used as a checklist when the product is analyzed, and are characterized by a simple and easy to understand analysis viewpoint concerning the product. Bruno states that product analysis needs to consider both personal value and object value (Bruno, 2007); however, he does not suggest concrete ways to do this. A product analysis learning method that integrates collaborative learning and a list of analysis items will solve this problem (Lin, Kato, 2011).

In this study, we propose a product analysis learning method that integrates collaborative learning and a list of analysis items (hereafter referred to as the "PA learning method").

2 PA Learning Method

This proposal offers an easier method for beginners to not only analyze a product through various aspects such as the appearance, technology, functionality, and ergonomics of the design, but also obtain an objective value by comparing individual results with others viewpoints. This aims to understand the intention of the product in a systematic and straightforward manner.

List of analysis items: Bruno's 24-items list is classified into 7 large categories (name, molding, material, essence, cognition, and whistles).

Collaborative learning: Because the subjective value of the learner is reflected in each analysis item, the results of analysis are different for each learner. Therefore, in theory, the understood value of the product becomes objective by consolidating the results and discussing the analysis.

We performed the experiment to evaluate the learning effects of the learning method proposal (Lin, Kato, 2011). The subjects were 80 university students in a design course. The following learning effects were observed: (1) even a beginner-level learner could carry out the analysis and (2) the product analysis clarified the direction of product improvement after the purpose of the product was understood. Meanwhile, we discovered certain limitations in our proposed method. Learners were

unable to understand how to effectively use the method because of a lack of sufficient explanation. Furthermore, the learners felt constrained because the direct use of the list of analysis items did not leave room for them to include their own ideas. Here, we studied the adequacy of the list of analysis items through a pilot experiment. In the pilot experiment, the learners analyzed the product through two methods, either with or without the list of analysis items. The cooperators were 4 university students in the design course.

As a result, two problems with the list of analysis items were discovered: (1) Learners thought that their own ideas were restricted when they consulted the list of analysis items in advance. Imagination and creativity are aspects emphasized in design education. For learners receiving such education, there is a consciousness that it is important to show their own ideas. Therefore, we can be assume that the checklist method felt restrictive. We thus improved the presentation method of the list of analysis items to respond to the imagination of the learners with the help of comments by learners. First, let learners think with their brains and give their own ideas as much as possible, and then let learners consult the list of analysis items when they cannot think of any more ideas. In this way, learners can think for themselves freely. Then, the viewpoints that he/she did not consider can be acquired from the list of analysis items. Furthermore, there awareness of problems and their imaginations deepen through discussion groups. (2) Students lost work hours because they could not initially understand the learning method, and the estimate of necessary hours was therefore wrong. Here, we took measures to explain the learning method and added content that had been lacking in the explanations of each stage before performing group learning. Furthermore, we responded by always announcing to the learners the working hours of each stage.

Table 1 shows the execution procedure of PA learning method.

First, procedure 0 was added before the conventional procedure 1, as there was no explanation about the learning method of this product analysis in the previous proposal. In this case, the explanation was added so that the learner could better understand the learning method before performing group learning. The contents were a training project outline, learning target, and learning implications. During each stage, the reasoning behind the subject and an explanation of the creation target were also added.

Procedure 1 explains the article name, unit price, and the function of the analysis object as advance preparation for analysis like before.

In procedure 2, participants elect a facilitator from the group. The role of the facilitator is to push the group's forward learning and summarize the results of the analysis as the MC for the group. Next, each group member assumes a specific user image and conducts product analysis as the user. The only improvement is adding an explanation about the technique of "user image" here.

The presentation method of the list of analysis items was improved in procedure 3. Conventionally, the list of analysis items was passed around, and learners analyzed a product by referring to it. In the improved procedure, time for learners to think freely was given before providing the list of analysis items. First, learners analyze the product from their own viewpoints. Next, the list of analysis items is distributed,

and learners examine items that they had missed while referring to the list of analysis items.

Procedure 4 is improved by first illustrating with an example the reasons and standards of theme selection. Problems are preferentially solved based on the result of learners' analysis, and the solution direction for the contents is decided like before.

Procedure 5 remains the same as before. When a theme is chosen, solutions for the elected problem are examined and ideas are provided. When no theme is decided in procedure 4, a suitable theme for ideas is attached here.

Table 1. Execution procedures of PA learning method

Procedure	Items	Contents
(0)	Presentation of the learning method	Explain about training project outline, learning target, and learning implications. Explain the reasoning of the subject and the creation target during each stage.
(1)	Presentation of an analysis object	Explain the essential information about the analysis object.
(2)	Selection of facilitator	Explain about the setting method of user image. Select a facilitator from among the members. Learners design their own user image.
(3)	Selection of analytical items and analysis of product	Analyze the product from learners own viewpoints. Refer to the list of analysis items, and add necessary items. Consult the list of analysis items by the analysis object and select necessary items. All the members discuss and examine the merit and demerit of the product from the viewpoint of user roles. The facilitator concludes a result of the analysis on the paper.
(4)	Decision of solution direction	Explain about the setting method of the theme. Pick the problems that seem to be important and determine the direction of the solution, Set a development goal of adequacy in the contents. (one may go to step (5) when the development goal cannot be decided)
(5)	Issue selection and devising solutions	In case the development goal is determined in step (4): devise a solution according to the development goal. In case the development goal is not determined in step (4): devise a solution and set a reasonable goal last.

3 Evaluation Experiment

We performed an experiment to evaluate whether the problems were resolved. Our evaluation focused particularly on whether a free exchange of opinions occurred mutually within a group and whether the study method was acquired, without the learner feeling any restrictions. The review methodology involved performing a trial

lesson using an enhanced method and considering the impact of these learning effects in order to compare the pre- and post-test results. The comparison of pre- and post-test results was conducted in terms of the abundance of ideas generated, their breadth, quality, and subjectivity evaluation aspects.

These results were then compared with those of group A (hereafter referred to as the "conventional groups") from the first experiment (Lin, Kato, 2011) in order to investigate the effect of improved learning methods (hereafter, the "improved groups"). In the first experiment, the experimental conditions determined four groups based on two factors: groups with or without the list of analysis items, and those using collaborative or non-collaborative learning. Group A used the conventional learning method: they were supplied with the list of analysis items and the learning was group-based.

The experimental methodology was as follows.

- Trial lesson: According to the above-mentioned improved learning method (Table 1), it experimented in lesson form. The course lasted 3.5 hours.
- Subject: The subjects were 16 students with an interest in product design in daily life. All participants were inexperienced with this type of learning method. In the lesson, they were divided into four groups comprising four students; by two groups replaced the analysis object of the pre-posttest and took counter balance.
- Implementing procedure: The implementation procedure involved the following five stages.

1. Explain the purpose of the experiment and let subjects write a cooperation agreement.
2. Distribute a specific product, two or three referential accessories, and associated standard documentation, analyze the object, and conduct a pre-test.
3. Use the lecture slides and teach the improved learning method to students, and then, let them implement the method in the group using the lecture slides.
4. Distribute a specific product, two or three referential accessories, and associated standard documentation, analyze the object, and conduct a post-test.
5. Let the students complete the questionnaire.

Firstly, in the pre-test, the homogeneity between groups and the validity of the comparison between the conventional and the improved methods were examined. The following aspects were consequently verified.

Effect on the Quantity and Quality of the Ideas. The pre-post-test comparison of the improved groups was conducted in terms of the number of analysis results and variations, and the content evaluation of the analyzed results.

Regarding the number of analysis results, each item pertaining to the adequacy or inadequacy of the product, which students filled out in the analysis sheets, was counted as a single unit. The analysis results were categorized, and categories with one or more items were assumed to be variations. The analysis results were evaluated in terms of the factors of "consent degree," "unique degree," and "importance." This evaluation was performed by college students who had not participated in this lesson;

these students evaluated the analysis results of one group in terms of each of the three factors in five steps. Inter-Rater Reliability was measured for thess evaluation results (Kuwabara, 1993) (Tsushima, 2010).

Effect of Improvement. The post-test comparison between the improved and conventional groups was performed in terms of the items of the number of analysis results and variations, and the content evaluation of the analyzed results using the two-sample t-test.

Post-test Questionnaire Comparison between the Improved and Conventional Groups. The analysis of the post-test questionnaire compared the improved and conventional groups, with the Mann-Whitney U test used to evaluate the improved effect of the subject factor in the improved groups.

4 Results

The verification of the homogeneity between groups for the improved methods for the product analysis revealed no significant difference. In the pre-test, the comparison between the improved and the conventional methods indicated no significant difference. Therefore, the two groups were not expected to show any differences regarding their product analysis capabilities, thus allowing the post-test of both groups to be analyzed.

4.1 Effect on the Quantity and Quality of the Ideas

As to the number of analysis results and variations, the pre- and post-test results were compared using each one-sample t-test. The results showed that post-test results were better than pre-test results in terms of the number of analysis results, with the difference being statistically significant ($t = 2.97$, $df = 15$, $p < 0.01$). Furthermore, the post-test results showed an improvement compared with the pre-test in terms of the number of variations, with the difference also being statistically significant ($t = 4.67$, $df = 15$, $p < 0.01$)(Table 2).

Table 2. The result of pre- and posttest-analysis of the improved groups. (( ) = standard variation, ** $p < 0.01$, * $p < 0.05$).

		Improved group n = 16		*t*-test two-sided
		Pretest (SD)	Posttest (SD)	*P*-value
The number of analysis result**		10.12 (4.27)	13.56 (4.26)	$P < 0.01$
The number of variation of analysis result**		4.69 (1.62)	8.13 (2.75)	$P < 0.01$
Contents evaluation of analysis result	Content degree*	9.50 (3.92)	12.13 (4.03)	$P < 0.05$
	Unique degree**	0.88 (1.59)	2.50 (1.59)	$P < 0.01$
	Importance*	10.13 (4.27)	13.25 (4.34)	$P < 0.05$

The credibiity factors obtained an assay result of a = .81 (number of items = 8) of interrater reliability by ICC for the results that evaluated contents of analysis by 8 raters. According to the standard of the credibility factor of Landis (1977), it is assumed that there is almost perfect within the range of 0.81~ (Landis, 1977).

Table 3. The number of the contents evaluation of analysis result. (*Content degree, Importance: Intermediate ≧ 3.00, Unique degree: Intermediate ≦ 3.00).

	Content degree (Unit : item)		Unique degree (Unit : item)		Importance (Unit : item)	
	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Improved group	**152**	**194**	**14**	**40**	**162**	**212**
Conventional group	182	212	30	52	182	216

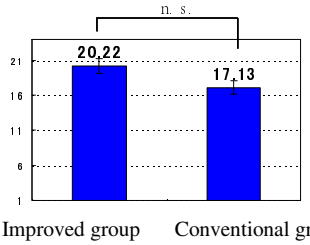

Fig. 1. The problem of the product could be found by analyzing the product

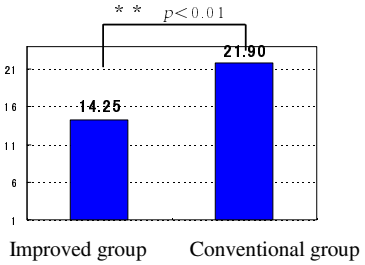

Fig. 2. It is useless to show the idea even if the product analysis was performed

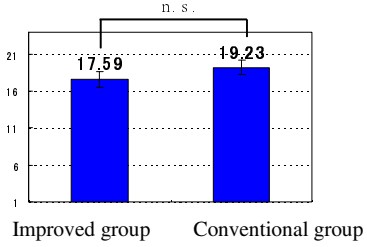

Fig. 3. An individual can analyze a product more objectively than in a group

For the content evaluations of the analyzed results (Table 3), the pre- and post-tests were compared using the one-sample t-test. The results revealed that the post-tests for the consent degree (t = 2.13, df = 15, $p < 0.05$), unique degree (t = 3.15, df = 15, $p < 0.01$), and importance (t = 2.66, df = 15, $p < 0.05$) were all improved as compared with the pre-test, with the difference being statistically significant.

Table 4. Pre-posttest comparison of the improved groups and the conventional groups. (( ) = standard variation, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$, n.s. = not significant).

		Improved group n = 16		Conventional group n = 20		*t*-test two-sided *P*-value
		Pretest(SD)	Posttest(SD)	Pretest(SD)	Posttest(SD)	
The number of analysis results		10.12(4.27)	13.56(4.26)	9.40(2.25)	11.85(3.54)	n.s.
The number of variation of analysis result *		4.69(1.62)	8.13(2.75)	4.15(0.88)	6.50(1.15)	p <0.05
Contents evaluation of analysis result	Content degree	9.50(3.92)	12.13(4.03)	9.10(2.40)	10.60(3.47)	n.s.
	Unique degree	0.88(1.59)	2.50(1.59)	1.50(1.28)	2.60(2.48)	n.s.
	Importance †	10.13(4.27)	13.25(4.34)	9.10(2.22)	10.80(3.72)	p <0.10

Table 5. The result of pre- and posttest-analysis of the conventional groups. (Lin, Kato, 2010) (( ) = standard variation, ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$, n.s. = not significant).

		Conventional groups n = 20		*t*-test two-sided
		Pretest (SD)	Posttest (SD)	*P*-value
The number of analysis result**		9.40(2.25)	11.85(3.54)	$P < 0.01$
The number of variation of analysis result**		4.15(0.88)	6.50(1.15)	$P < 0.01$
Contents evaluation of analysis result	Content degree*	9.10(2.40)	10.60(3.47)	$P < 0.01$
	Unique degree**	1.50(1.28)	2.60(2.48)	$P < 0.10$
	Importance*	9.10(2.22)	10.80(3.72)	$P < 0.00$

4.2 Effect on Analytical Abilities

The post-test results for the improved groups were compared with those of the conventional groups using the t-test in term of the number of analysis results, number of variations, and content evaluation of the analyzed result.

The analysis revealed that there was no significant difference between the improved and conventional groups in terms of the number of analysis results ($t = 1.32$, $df = 34$, n.s.). In contrast, a statistically significant increase was observed in the improved groups compared with the conventional groups in terms of the number of variations ($t = 2.21$, $df = 19.16$, $p < 0.05$). In addition, the factor of importance in the post-test showed a significant improvement in the improved groups compared with the conventional groups($t = 1.82$, $df = 34$, $p < 0.10$)(Table 4).

4.3 Subjective Factor Verification

The post-test questionnaire compared the results between the improved and conventional groups using the Mann-Whitney- U test. For the item “The problem of

the product could be found by analyzing the product," the average score for the improved groups was 20.22, versus 17.13 in the conventional groups. On average, the improved groups showed a greater improvement, but it was not statistically significant ($U = 132.5$, $p = .386$, n.s.) (Fig. 1). Regarding the item "It is useless to show the idea even if the product analysis was performed," the average score for the improved groups was 14.25 compared with 21.90 in the conventional groups, thus showing better results for the improved groups ($U = 92$, $p = .030 < 0.01$)(Fig. 2). For the item "An individual can analyze a product more objectively than in a group," the average score for the improved groups was 17.59 versus 19.23 in the conventional groups. Although the improved groups had lower scores on average, the difference was not statistically significant ($U = 145.50$, $p = .848$, n.s.) (Fig. 3).

5 Discussion

5.1 Learning Effects

In the conventional learning method, the list of analysis items was shown to students before they were asked to complete the task. In the improved methods, the usage of this list was altered, and students' independence respected, as they were given the list after completing the test. Consequently, the interaction between students was strengthened.

Regarding the number of analysis results and variations, the comparison of the pre- and post-tests of the improved groups showed that they improved over time. This result was the same for the conventional groups (Table 5). From these results, we see that the improved methods had the same effect as the conventional methods in term of teaching analytical abilities. Moreover, even beginners were able to analyze a product from a multi-perspective.

In terms of the quality of the analyzed contents, the post-test results for the improved methods (consent degree, unique degree, and importance) were significantly improved compared with the pre-test. In the conventional groups, the post-test for the consent degree and importance were significantly improved compared with the pre-test, although the post-test for the unique degree did not (Table 5). From these results, it can be said that the improved learning method was more effective than the conventional learning method in terms of the uniqueness of product analysis.

Moreover, the improved groups performed significantly better than the conventional groups with regard to the number of variations and content evaluations (importance). It can therefore be said that the learning effect of the improved methods was greater than the conventional methods from the perspective of the analysis and quality of the analysis.

5.2 Subjective Factor Verification

For the item "The problem of the product could be found by analyzing the product," the improved groups showed an improvement from the average value, but the

difference was not observed subjectively. Based on the questionnaire with the conventional methods (Lin, Kato, 2011), the results for the groups given the list of analysis items (average for group A was 3.45 and group C 3.40 (the conventional methods)) were significantly lower than those for groups without the list (average for group C was 3.60 and group D 3.80). The average for the improved groups was 3.63. These results cannot be directly compared with those of groups B and D, which did not have the list of analysis items. However, the average value, which reveals that the significant difference has been disappeared, indicates that the improved method has certain effect.

Regarding the item "It is useless to show the idea even if the product analysis was performed," the improved groups showed a significantly greater improvement compared with the conventional groups ($U = 92$, $p = .030 < 0.01$) (Fig.2). Therefore, it can be said that the student's feeling of being restrained by the list of analysis items was reduced by using the improved list of analysis items.

Concerning the item "An individual can analyze a product more objectively than in a group," the improved groups performed better than the average, but the difference was not significant. However, based on the questionnaire using the conventional methods (Lin, Kato, 2011), the results for the groups with collaborative learning (average for group A was 1.85 and group B 1.45 (the conventional methods)) were significantly higher than those for the non-collaborative groups (average for group C was 1.50 and group D 1.45). The average of the improved groups was 1.50. This result cannot be directly compared with non-collaborative learning Groups C and D. However, a constant trend was observed namely that collaborative learning allowed students to analyze a product more objectively because the disappeared significant different was seen from the average value comparison.

6 Conclusions

In this study, we proposed a learning method for product analysis by combining a collaborative learning approach with a list of analysis items.

Based on the experiments, the following learning effects were verified: (1) even a beginner can carry out an analysis from the multi-perspective and achieve improvement in analytical abilities, (2) product analysis clarifies the direction for product improvement after the purpose of the product is understood, and (3) product analysis could be useful for identifying problems with a product.

Although the learning method proposed in this study is targeted at learners who study design, novice designers employed by companies may also benefit from it. In that case, it is necessary for designer to understand the characteristic of an analysis object after a comprehensive analysis on the product, rather than from the perspective of the designer. Although a preliminary evaluation of the learning effect has not been carried out yet, we would like to one of the study tasks.

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