Quantitative Evaluation Enabling to Visualize Design Process for Product Design Education

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Abstract

Design evaluation, especially product design evaluation, used to be performed by some kind of professions for design authority who has been considered to be famous and well-established at that relevant fields. Almost all designers, who want to design by themselves, sometimes had to be obeyed to such professions and design authority, but they had no special information such as how to improve their design results and/or how to modify theirs into more acceptable ones by means of decision by such professions and authority. It seems that the reason is that the evaluation of the design sometimes includes the subjective evaluation of the evaluation side.

From the author's own experience, it could be said that there might be a few viewpoints for evaluation criteria on the evaluation sides. Therefore, if not always, such evaluation criteria are frequently reflected in the fact that there are differences from case to case. Naturally, there are things that are sensuously, subjectively, and arbitrarily described as "cool" or "beautiful," so we do not intend to deny such so-called instinctive subjectivity. However, "design" should be an accurate response to the needs of the owners or the market, who actually want or obtain outputs from design, so design itself is to be decisively different from "art" that pursues pure beauty and unique expression.

Some kinds of ambiguity in design evaluation that many designers have felt frequently can be said to be the same at Design Education sites, which means not only design course of art universities but also how to teach "learning design". The evaluation (judgment of good or bad) used to be made by the subjective evaluation of the evaluators (sometimes, teachers) for the design proposal or results which had been made by the learners. In such a case, evaluation of design sometimes introduced a big difference. Learners' anxiety increases more and more when they do not know what criteria are employed to determine a good design. It is clear that such ambiguity contributes to the confusion of learners in designing. Namely, we have been suffering from existence of ambiguity in design evaluation from the school days of learning design. We would like to decrease such unnecessary ambiguity in design evaluation.

In order to solve these problems, it is necessary to create a mechanism to evaluate design quantitatively (in the field of design education to learn design). This is different from the subjective and instinctive evaluation of beauty (judgment of good or bad). In other words, the objective in this research to create a mechanism that allows any evaluator to obtain the same evaluation to some extent.

For the sake of construction of quantitative evaluation methods, it is necessary to trace the

relevant process of determining the design and recognize how selection and/or determination finally produced design goals. For example, by means of clarifying how the design creator made the design, it should be possible to understand the intention of the creators namely designers as to how honestly they are responding to their needs.

Based on the previous experience so far, it had been not so important to know and/or understand why his design has been adopted in the process of design decision nor how this design proposal has been decided, and so on. The process leading up to completion has been left unclear, after completion. There was a current situation where it was left unreasonable. It is necessary to visualize such a buried and unclear process in order to trace the relevant process of determining the design and recognize how selection and/or determination finally produced design goals. We are aiming to visualize the process as an effective way to quantitatively evaluate the finished design.

We introduce three practical research examples. The first example is to describe an attractive approaches to design in Ecological and/or Recycling methods. It is to utilize and discover tools and resources for creation of some reusable objects. It is important to provide not only knowledge but also techniques in efficient and effective ways. Students of the design education course also need to learn both of knowledge and techniques, the former is necessary to design some objects and the latter are essential to utilize tools as well as equipment.

The second example presents a proposal to reconstruct some specific towns which were attacked and destroyed by Huge Tsunami, for example, in Tohoku region of Japan on the 11th of March, 2011. A collaborative approach has been employed to provide some trial proposal to reconstruct such damaged towns by means of Internet community as follows;

a)providing a proposal and pictures to reconstruct, especially offering visual design concept of living space for slope topography through social network system as an example of Internet community,

b)consulting and discussing the above proposal and pictures among specific Internet community with analysis by Kansei Engineering, and

c)improving an original proposal into more efficient and flexible one.

The third one is Collaborative design which is a good approach to obtain good results together with team and/or group efficiently and effectively. Our focused problem is to build the large scale poster for college promotion and the publicity of entrance examination. The mission of building poster is important, therefore it is necessary to do information sharing as well as

decision making in order to realize good performance and accountability in the process of design collaboration.

Based on these example, we have recognized necessity of some scheme to acquire user ' s requirement and tendency of likeness. Therefore, we have developed a Web-based questionnaire system to provide question and to obtain answer to/from specified users in order to utilize collaborative design approach.

Collaborative design is a suitable approach to obtain useful and practical results within a group of people in a relatively short period. Since the design process can involve complex decision-making variables, traceability and confirmation are very important to validate the consistency of decision making toward results design. It will be remaining how to confirm and visualize the designed results in quantitative procedure, although we have decided to employ Kansei Engineering to achieve a respectable performance of collaborative design and to apply it to Web system for decision-making.

We will describe our approach and its trial solution to demonstrate consistency in evaluating product design based on collaboration using the Analytic Hierarchy Process (AHP)-based calculation for confirmation. And we are sure that we will be able to extend our same approach and solution about utilization of Kansei Engineering-based product design and Quantitative verification of designed results through AHP methodology to more useful fields of education not only in product design but also other attractive ones.

In this paper, we propose a quantitative evaluation method for product design education that enables visualization of the design process, and then we verify its effectiveness through case studies. In design education, apart from the subjective evaluation of teachers, it is required to create a mechanism to evaluate design objectively and quantitatively. In particular, it is extremely important for education to be able to quantitatively confirm the decision-making process of what kind of decision-making the produced design has undergone. Because the design process as a collaborative effort can involve complex decision variables, traceability and quantification are essential to be able to verify the consistency of the resulting design decisions. Therefore, we applied the Analytic Hierarchy Process (AHP), which can quantitatively handle qualitative factors such as sensibilities and preferences, to an Web-based decision-making system related to design. And, we propose a mechanism to structure, quantify, and visualize the process which made decisions related to design. After that, we will discuss the necessity and significance of visualization of the design process and quantitative evaluation of three practical research cases

for students of the design education course, and apply the proposed quantitative evaluation method. We are verifying its effectiveness and usefulness.

1 Introduction

1.1 Background of this research

In Japan, it seems that more attention has been paid to product performance than product design. Although the former had been considered to be one of the most important bases of industrial technologies, the latter was thought to be strongly dependent on the "outside" appearance of a combination of shapes and colors. In industry and elsewhere, product design was considered simply superficial and eventually less important than product performance, which includes many things such as mechanisms, methods, materials, and know-how. So product design has been treated in our industry as having only the secondary importance in comparison with product performance.

In recent years, when the performance of products in China and ASEAN countries approaches that of Japan, it becomes probably impossible to maintain our superiority with performance alone, and the importance of design is attracting attention for differentiation. Efficient ways to improve product design are beginning to be discussed in order to continue this design excellence. Recently, the importance of design has finally been recognized in industry, not only for its attractiveness based on its "external"appearance but also for its artistic and strategic significance. So far, the authors have considered that an environment suitable for product design education is necessary to realize effective instruction and education in product design.

The importance of design is not limited to the "design" issue, but extends to the broader "intellectual property" and "industrial technology" issues. The "recent slump in Japanese companies" seems to be due to the weakness not from engineering education but from design education. These are sometimes heard from foreign countries and/or the business community, as will be described later.

Of course, there may be many causes, but it can be said that the performance supremacy principle that "if the performance is good, there will not be complained at all" has reached its limit. With good performance only, it has already long been difficult to find a win after win result by means of a single design against the complex and diverse requests, hobbies and tastes of the market.

Design evaluation, especially product design evaluation, used to be performed by some kind of professions and so-called design authority who have been almost considered to be famous and well-established at that relevant fields. Probably all the approximate designers, who want

to design by themselves, had to or would like to be obeyed to such professions and/or design authority in our traditional manner. But many of such designers had usually received no special information from evaluation by the above professions and design authority, namely, for example, how to improve their design results, how to modify theirs into more acceptable ones, how to correct included not-suitable-ones, and so on by means of decision provided from such professions and authority. It seems to us that the reason for decision or selection used to be subjective and not consisted because the evaluation of the design sometimes includes the subjectively evaluated and not consistently performed by the evaluation side.

It should be necessary to "discuss and activate design education" in the field of educational technology as well as to raise the level of design education. Therefore, we introduced our precedent cases regarding the current state of design education. We would like to start a discussion based on the feedback from students who are taking actual design education. How can we collect student needs and improve our education situation for product design even at the elementary level of design education ?

Education, especially design education, needs combination of knowledge, technique and exercise. Because students of the relevant education course must have suitable knowledge to design some objects as well as applicable techniques to produce original shape and structure for the self-designed objects. In order to grow their knowledge and techniques during the effective course, students, namely learners want to face some practical designing and producing situation as exercises which shall be able to provide very important experience for the relevant students/learners.

If they find themselves in successful results, they will really gain possession of skills, great experience, self-confidence and moreover applicable challenging spirits for other targets. In these cases, there may be some problems how to support and realize their fruitful courses and how to reduce/shorten their reasonable periods for the total length of courses. Many students/learners need different knowledge and materials and they want to face several kinds of target and plans to design and implement their objects. We have focused on Kansei Engineering and Utilization of network in order to realize useful product design education.

Kansei Engineering is one of the most powerful methods that have certain capabilities to quantify various customer requests and requirements into countable and/or numerically analyzable forms and derive many kinds of design specifications. Although it previously seemed to be very difficult that design targets could be treated with the quantitative procedures, Kansei

Engineering would provide a very smart and possibly acceptable solutions for our circumstances by means of its powerful productivity. Until now, we have succeeded in calculating design indicators and bringing satisfaction to more users by quantifying and formulating users' demands and requests in various situations through Kansei Engineering. Notation of "users" in the above expression and after are sometimes used as representative delegates of owners, customers, consumers and the relevant market for the design targets.

As mentioned in the paper, the design specifications can be derived by quantifying and formulating the "requirement specifications" that have been described in qualitative expressions. In addition, many product designers have adopted Kansei Engineering methods, proposed a wide variety of product designs to the society and achieved a lot of significant designed results, which will be able to be accepted for many, many users. Producers, who could not accurately obtain users' requests even in design and, as a result, could not provide appropriate products until then, would realize good performance to provide useful design with utilizing Kansei Engineering methods because such proposed design and such results will very frequently used to guarantee subsequent results in a real world.

Collaborative design is another very powerful design procedure. With many collaborators, we will be able to overcome several difficulties and accomplish possible successes in a relatively short period. For that purpose, it is very useful to utilize the network, especially network community, effectively and efficiently. By utilizing the network community, it is possible to appropriately obtain collaborators and facilitate mutual communication through network connectivity, so collaborative design and utilization of the network community are really inseparable and very much precious for adequate productivity.

From a few our own experience, it could be said that there might be some situation-dependent viewpoints for evaluation criteria on the evaluation sides. Even though not always, such evaluation criteria would be frequently reflected in the corresponding fact that there are differences from case to case. Naturally, there are things that are sensuously, subjectively, and arbitrarily described as "cool" or "beautiful," so we do not intend to deny such so-called instinctive subjectivity. However, "design" should be an accurate response to the needs of the owners, customers or related market, who actually want or obtain outputs from design. The design itself is to be definitely different from "art" alone that pursues pure beauty and unique expression for itself.

Some kinds of ambiguity in design evaluation that many designers have felt frequently can be said to be the same at Design Education sites, which means not only design course of art

universities but also how to teach and instruct "design education and learning". The evaluation (judgment of being good or bad) used to be made by the subjective evaluation of the evaluators (sometimes, teachers and/or prior/senior designers) for the design proposal or results which had been made by the learners.

In such cases, evaluation of design sometimes introduced a big difference and then brought several results to the learners of design, namely such results might probably induce and cause some kinds of complicated impression on the learner sides. Learners' anxiety increases more and more when they do not know what criteria are employed to determine a good design. In other words, it is clear that such ambiguity contributes to the confusion of learners in designing.

We have been suffering from existence of ambiguity in design evaluation from the school days of design learning. We would like to decrease such unnecessary ambiguity in design evaluation, especially in product design education.

1.2 Objective in this Research

Based on the previous experience so far, it had been not so important to know and/or understand why his design has been adopted in the process of design decision nor how this design proposal has been decided, and so on. The process leading up to completion has been left unclear, even after design process has been completely performed. There was a current situation where it was left unreasonable.

In order to solve these problems such as ambiguity of design evaluation, inconsistency of determination in design process, Learners' anxiety for design education and so on, we are aiming to visualize the process as an effective way to evaluate the finished design in a quantitative procedure. It is very important to visualize such a buried and unclear process about related design matters in order to trace the relevant process of determining the design and recognize how selection and/or determination finally produced design goals. For example, by means of clarifying how the design creator made the design, it should be possible to understand the intention of the creators namely designers as to how honestly they are responding to their needs. For the sake of construction of quantitative evaluation methods, it is necessary how to establish some kind of traceability of determining process to select and choose a certain alternative from similar candidates among design factors. Therefore, it is necessary to create a mechanism to evaluate design quantitatively (in the field of design education to learn design).

The objective in this research is to create a mechanism that can let many evaluators smoothly

employ their evaluation criteria for judgment of design, and at the same time provide easily acceptable evaluation criteria to product design education, which will be able to bring up learners in design more than in the previous situation of design education.

Kansei Engineering-based design and Network community-assisted Collaboration have been adopted to establish our Design Education environment, so these design approach is one of our proposed methodologies to demonstrate a fruitful design products through our some practical experience. Kansei Engineering-based design can support high-quality product design and user friendly design strategy. Network community-assisted Collaboration can provide flexible and widely-acceptable design product in a relatively short period. Kansei Engineering-based design and Network community-assisted Collaboration have been introduced as a smart methodology and proposed to be very much useful and powerful scheme of product design education in this Dissertation.

Although Kansei Engineering and Network community-based Collaboration have been considered to be useful methodologies for product design, there are still remaining inconsistency of determination in design process, which seems to be some kind of ambiguity in evaluation process, and to cause probably Learners for anxiety against design education. In general, decision making is some kind of process to choose among alternatives based on multiple criteria. In each of these decisions, even during Kansei Engineering procedure deeply in our mind, we have several factors or criteria on what to consider and we also have several alternatives choices that we should decide. On group decision making, for example, such a case corresponding to Network community-based Collaboration, these criteria and alternatives are more obvious and must be determined first before we give some judgment score or evaluation values on them. In these above notations, the word ‘factors’ and ‘criteria’ have been used interchangeably. Similarly, people say that they frequently use ‘alternative’ and ‘choice’ for the same meaning.

The determination of criteria and alternatives seem to be very subjective. Notice that the group of criteria and alternatives above are not exhausted, namely imperfect. They neither cover all possible criteria nor all possible alternatives. There is no correct or wrong criterion because it is subjective opinion. Different people may add or subtract those lists. Some factors may be combined together and some criterion may be broken down into more detail criteria. These assumption will be suitable for determination in design process. Frankly speaking, the explanation is to be prepared for the Analytic Hierarchy Process (AHP) in its famous tutorial.

The main advantage of AHP is its capability to check and reduce the inconsistency of expert

judgments. While reducing bias in the decision making process, this AHP method provides group decision making through consensus using the geometric mean of the individual judgments. AHP derives scales of values from pairwise comparisons in conjunction with ratings and is suitable for multi-objective, multi-criteria, and multi-actor decisions with any number of alternatives. AHP involves assessing scales rather than measures; hence, it is capable of modeling situations that lack measures (e.g., modeling risk and uncertainty). AHP is comprised of three main principles: decomposition of the structure, comparison of judgments, and hierarchical composition (or synthesis) of priorities. Decomposing a decision problem into its constituent parts facilitates building hierarchies of criteria to determine the importance of each criterion.

Most of decisions makings are based on individual judgments. As we try to make our decision as rational as possible, we need to quantify these subjective opinions into subjective values. The values are number within any certain range; say from 1 to 10. The values can be any number with order (ordinal number) and you can even put different range for each factor. Higher value indicates higher level of the factor or preferable values. Now you see that not only the criteria and alternatives are subjective, even the values are also subjective. They are depending on you as designer in the case of decision making.

Determination in the design process would bring and introduce designers to the several methods on multiple criteria decision making (MCDM). One of the most famous, powerful and quantitative methods of MCDM is called Analytic Hierarchy Process or AHP in short. The AHP procedure had been applied for Decision Support System (DSS), including data mining and machine learning and so many applications. It can involve both subjective human judgments and objective evaluation merely by Eigen vector and examine the consistency of the evaluation by Eigen Value.

We can assume our design evaluation model where several decision making in the process of designing involves multiple criteria. Some design idea will include and display characteristics that make certain factors, which involve multiple criteria, too. AHP has been sometimes suggested as a powerful tool for implementing a multiple criteria decision making in a quantitative manner. So it can be utilized to perform structuring and clarifying the relations and importance between multiple criteria and decision making, even including subjective human judgment. Therefore, one of the main proposals of this Dissertation is to employ such an AHP approach to calculate relatively subjective designers' decision making and/or also subjective evaluators' multiple criteria.

1.3 Organization of this paper

We introduce three practical research examples. The first example is to describe an attractive approaches to design in Ecological and/or Recycling methods. It is to utilize and discover tools and resources for creation of some reusable objects. It is important to provide not only knowledge but also techniques in efficient and effective ways. Students of the design education course also need to learn both of knowledge and techniques, the former is necessary to design some objects and the latter are essential to utilize tools as well as equipment.

The second example presents a proposal to reconstruct some specific towns which were attacked and destroyed by Huge Tsunami, in Tohoku region of Japan on the 11th of March, 2011. A collaborative approach has been employed to provide some trial proposal to reconstruct such damaged towns with Internet community as follows; a) providing a proposal with pictures to reconstruct through social network system as an example of Internet community, offering visual design concept of living space for slope topography, b) discussing the above proposal and pictures among SNS with analysis by Kansei Engineering, and c) improving an original proposal into more efficient and flexible one with support from SNS.

The third one is Collaborative design which is an approach to obtain good results together with team and/or group efficiently and effectively. Our focused problem is to build the large scale poster for college promotion and the publicity of entrance examination. The mission of building poster is important, therefore it is necessary to do information sharing as well as decision making in order to realize good performance and accountability in the process of design collaboration.

Based on these example, we have recognized necessity of some scheme to acquire user ' s requirement and tendency of likeness. Therefore, we have developed a Web-based questionnaire system to provide question and to obtain answer to/from specified users in order to utilize collaborative design approach.

Collaborative design is a suitable approach to obtain useful and practical results within a group of people in a relatively short period. Since the design process can involve complex decision-making variables, traceability and confirmation are very important to validate the consistency of decision making toward results design. It will be remaining how to confirm and visualize the designed results in quantitative procedure, although we have decided to employ Kansei Engineering to achieve a respectable performance of collaborative design and to apply it to Web system for decision-making.

We will describe our approach and its trial solution to demonstrate consistency in evaluat-

ing product design based on collaboration using the "Analytic Hierarchy Process(AHP)" -based calculation for confirmation. And we are sure that we will be able to extend our same approach and solution about utilization Kansei Engineering-based product design and Quantitative verification of designed results through AHP methodology to more useful fields of education not only in product design but also other attractive ones. We will illustrate an overview and organization of this PhD dissertation below.

① Introduction:
An introduction, which includes this subsection, presents a background of this research and an overview of this Dissertation paper.

② Practical Design Examples:
They can illustrate how to perform productive design in the case of ecological reproduction, material and knowledge sharing, SNS-based information sharing and decision making for collaboration, Kansei Engineering based product design methodology.

- "Section 2" : Reproductive Design Education based on Knowledge and Resource Discovery through SNS. (red colored part of Figure 1)
- "Section 3" : Collaborative Design and its concept to Build Living Space for Slope Topography through Kansei Engineering approach. (purple colored part of Figure 1)
- "Section 4": Kansei Engineering-enhanced Collaborative Design of Promotion Poster. (green colored part of Figure 1)

③ Web-based Questionnaire System and its Application:
We have developed Web-based Questionnaire system for semi-general purpose information sharing and decision-making described in the section 5, which is indicated with blue colored part of Figure 1.

④ Analysis and Confirmation:
And we need systematic confirmation scheme for analysis and visualization for evaluation for the results generated from Collaboration demonstrated in the section 6, which is highlighted by brown colored part of Figure 1.

⑤ Discussion:
And we will show some topics of necessary discussion for this dissertation through our research.

⑥ Conclusion:
And we have to summarize our research conclusion of this Dissertation.

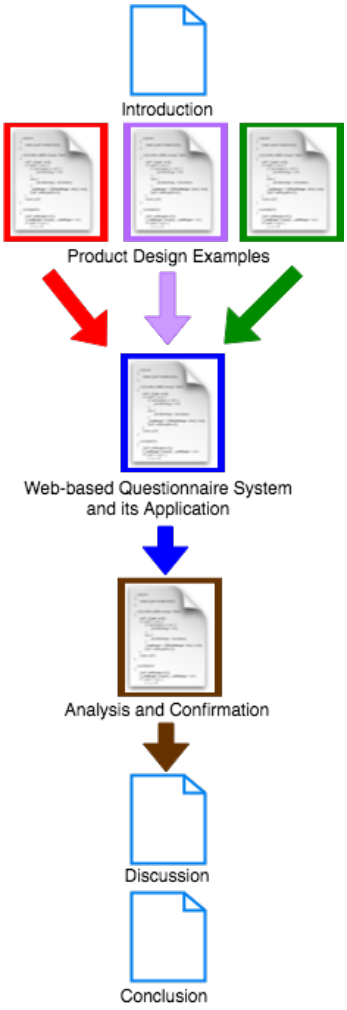


Figure 1: Overview and Organization of this Dissertation.

2 Proposal of Reproductive Design Education based on Knowledge and Resource Discovery through SNS Community

2.1 Background of this section

Education, especially Design education, needs combination of knowledge, technique and exercise. Because students of the relevant education course must have suitable knowledge to design some objects as well as applicable techniques to produce original shape and structure for the self-designed objects. In order to grow their knowledge and techniques during the effective course, students, namely learners want to face some practical designing and producing situation as exercises which shall be able to provide very important experience for the relevant students/learners. If they find themselves in successful results, they will really gain possession of skills, great experience, self-confidence and moreover applicable challenging spirits for other targets. In these cases, there may be some problems how to support and realize their fruitful courses and how to reduce/shorten their reasonable periods for the total length of courses. Many students/learners need different knowledge and materials and they want to face several kinds of target and plans to design and implement their objects. This research has focused on utilization of network community to quest for suitable knowledge and discover desired resources in order resolve given/own problems. Network sometimes shows a lot of scenes to its users, from domestic LAN to wide WAN namely Internet. Currently, social networks become more and more applicable for the users to achieve information sharing and exchanging.

2.2 Related Works of this section

There is a report for four useful articles of related works of this section. These articles focuses on case study about how to utilize SNS community for information sharing, decision making and so on.

Sue Yeon Syn of The Catholic University of America and Sanghee Oh of Florida State University report why SNS (social network site) users do share information, knowledge and experience on Facebook and Twitter[201]. Their study examined why SNS users shared information, knowledge, and personal experiences with others on SNS. Through an online survey, 10 motivation factors were tested with Facebook and Twitter users. Their findings indicated that the motivations of SNS users in sharing information could be attributed to various aspects such as demographic characteristics, experiences of SNS and Internet usage, as well as the charac-

teristics and features of SNS. SNS users could be highly motivated by the learning and social engagement aspects of SNS services. They also found that the motivations could vary depending on the characteristics of services. They said that results of their study could be helpful for researchers in understanding the underlying reasons for social activities as well as for SNS developers in improving SNS services.

Slava Kisilevich from University of Konstanz, Germany et al. reported that online social network services (SNS) provided an unprecedented rich source of information about millions of users worldwide[202]. However, most existing studies of this emerging phenomenon were limited to relatively small data samples, with an emphasis on mostly "western" online communities (such as Facebook and MySpace users in Western countries). In order to understand the cultural characteristics of users of online social networks, their paper explored the behavioral patterns of more than 16 million users of a popular social network in the Russian segment of the Internet, namely, My.Mail.Ru (also known as "My World" in Russian). Their main goal was to study the self-disclosure patterns of the site users as a function of their age and gender. Their paper compared the findings of their analysis to the previous studies on Western users of SNS and discussed the culturally distinctive aspects. Their study highlighted some important cultural differences in usage patterns among Russian users, which called for further studies in SNS in various cultural contexts.

Ohbyung Kwon and Yixing Wen from Korea explained Social network services which were emerging as a promising IT-based business, with some services being provided commercially such as Facebook[203]. However, it was not yet clear which potential audience groups would be key social network service participants. Moreover, the process showing how an individual actually decided to start using a social network service might be somewhat different from current web-based community services. Hence, the aims of their paper were twofold. 1) They empirically examined how individual characteristics affected actual user acceptance of social network services. To examine these individual characteristics, they applied a Technology Acceptance Model (TAM) to construct an amended model that focused on three individual differences: social identity, altruism and telepresence, and one perceived construct: the perceived encouragement, imported from psychology-based research. 2) They examined if the users' perception to see a target social network service as human relationship-oriented service or as a task-oriented service could be a moderator between perceived constructs and actual use. They said their result discovered that the perceived encouragement and perceived orientation are significant constructs

that affected actual use of social network services.

Tristan Henderson, Luke Hutton & Sam McNeilly of University of St Andrews, UK reported about "Ethics in online social network research"[204]. They described that Social network sites (SNS) and other online social networks such as Facebook and Twitter represented a huge source of data for research in many fields, including sociology, medicine, anthropology, politics and computer science. Such sites might contain sensitive information and care needs to be taken when designing experiments or collecting SNS data. This case study outlined two such experiments and discussed the ethical concerns within. They described lessons learned, a set of experiments designed to test some of these lessons, and an architecture that addressed some of the ethical challenges.

From these articles, it is confirmed that we had better utilize knowledge and techniques of SNS community. And at the same time we must choose and/or determine more useful and reliable ones among the proposed knowledge and information from SNS community.

2.3 Real Production Process for Furniture

A real production process of furniture includes the following steps;

1. Design of the target furniture: normally, some prototyping is necessary in the design process. Making miniature is a part of prototyping. It is convenient for overviewing such a target furniture.

2. Discussion of the target furniture: Designer and sale manager discuss the profile about the target furniture by means of miniature as a prototype. Some sale plan is to be prepared by means of prototyping, namely using miniature.

3. Production of the target furniture: After prototyping and discussing, producing process begins in accord with previous processes. Display and trial usage will be available with finished product.

Figure 2 shows prototyping a miniature of reference furniture on the work desk. In this case, prototyping includes coloring of miniature. Suitable coloring may be good for the sake of giving reality to miniature. Scaling of miniature will be from 1/10 to 1/8 possibly.

Figure 3 presents the according miniature of furniture with the same kind of miniature of seat sofas which have been made up of "foam polystyrene" because of easy forming. Such a

Figure 2: Prototyping and coloring of miniature for target furniture.

prototype, however, may give someone a quality feeling so that some people say there is no special need to utilize Virtual reality rendering with expensive effect by computer.

Figure 3: Display and evaluation with miniature of furniture.

Figure 4 displays a real model of furniture which is produced based on miniature after prototyping. A real model must be good and useful if previous prototyping is well-discussed and suitable enough to produce real furniture.

As comparison with Figure 3 and Figure 4, not only designer(s) but also sale manager(s) can feel that real production is identical with prototyping miniature. As a consequence, potential buyers who may stand at the same position of sale manager can recognize and decide to pay their costs to buy the relevant furniture only through reference of prototype. As you know, not

Figure 4: Production of furniture based on miniature.

a few people sometimes buy products only with reference of catalogs or online browsing, instead of touching and checking real model.

2.4 Proposal of Reproductive Design Education using SNS Community

Network communities have been attractive and useful for us to perform information exchanging and sharing among the registered people who are living in the distance. If one describes some resource is unnecessary in one's community, others may rely those resources must be necessary in the other's community. And if one asks some questions which need knowledge to be resolved, others may reply the relevant answers which include suitable knowledge for resolution. SNS community is one of the efficient and effective environments which can transfer information to the relevant position/ people. In order to perform resource recycling and discovering, it is very good to utilize SNS community and carry out information exchanging and sharing on the networks. In the case of our proposal design education, recycling resources of materials has been focused and illustrated in order to reproduce some useful products with recycled resources. We will explain sample of utilization of SNS community, decision making on the networks (i.e. resource finding, knowledge obtaining to redesign, presenting by miniature, discussing, etc.), reproduction of real model, and evaluation. Generally speaking, reproduction of furniture may be included with the following procedures, namely,

1. Designer reforms his/her original model into a new one, which has both of a part of the same resources of the original model and other new parts.

2. The designer must decide to keep what part of original resources and to design others newly.

3. In order to decide to keep what part of original resources, it is necessary to retrieve past results. On the other hand, in order to decide to create new part, it may need to search future trends, namely, prediction of trend.

4. The former must utilize retrieval of past track records just like as one of database applications, while the latter had better employ market research, trend watching, questionnaire investigation for users and so on.

Of course, it is very difficult for only one or a few designers to manage the above procedures efficiently. Several staffs and/or support team must be necessary for such designer(s).

We describe schematic procedure for reproduction during Design Education using SNS community in order to improve effectiveness and efficiency educational results.

- In order to accomplish retrieval of past track records, we have utilized SNS community. Such a community can play important roles to provide huge and excellent database for retrieving.

- We have also utilized SNS Community to perform market research, trend watching, questionnaire investigation, and user's demands. Probabilistically speaking, small size of SNS community may have not large demands but steady ones even for productions.

- We have employed SNS community as suitable media to perform information sharing and exchanging. Namely, some members of Social networks may be able to provide and/or point out both of resources and know-how for reproduction in Design Education.

- As described before, values of people may be not similar and identical. If so, it must have possibilities that something which is unnecessary for someone is necessary for other ones from the global viewpoints.

- specially, recycling will be more and more popular in many fields and probably be dominant. Production, such as furniture, has relatively long lifetime such as 10 years or more, so those resources may be useful and available for multiple generation users. The problems are how to adjust changes and variation of their tasty, favorites and trends.

2.5 Advantages of Proposed Design Education

This section demonstrates characteristics and advantages of our proposed design education showing practical reproduction processes of furniture as a sample of recycling resources. It also includes workflow of real reproduction, explanation of detailed stages for reproduction and modeling of knowledge and resource discovery using SNS community.

2.6 Workflow of Practical Reproduction

First of all, workflow of reproduction of furniture can be summarized as follows. Such workflow utilizes resources and know-how using SNS-based human relation. All the operations and functions are especially geared towards SNS and intended for users of the relevant SNS community.

- Furniture Designing stage:

  A) Analyzing needs/demands

  B) Choosing kinds of furniture

  C) Determining kinds of materials

- Resource Finding stage:

  A) Requesting information about furniture to be constructed

  B) Requesting information about materials of the furniture

  C) Searching resources for materials/furniture

  D) Obtaining information about resources

  E) Obtaining information about resources

- Knowledge Collecting stage:

  A) Requesting information how to fabricate, manufacture and/or process such resources

  B) Searching knowledge for fabrication, manufacturing and/or processing

  C) Obtaining knowledge about the above techniques

  D) Accumulating knowledge like database

- Furniture Constructing stage:

  A) Selecting staffs and/or work places

  B) Pouring resources and know-how into the above factory (i.e. workplace with staffs)

  C) Reproducing the relevant furniture

The above workflow can be separated into 4 major stages, which includes some more detailed steps.

2.7 Reproduction Modeling for Proposed Design Education with Knowledge and Resource Discovery in SNS Community

We have utilized SNS community in order to obtain "Requests", "Resources", "Knowledge" and "Announcement" for Modeling for Proposed Design Education. Our sample is to reproduce some furniture using Knowledge and Resource. They can be retrieved and discovered in SNS community. At first, we have established Human relation for demand analysis, trend retrieval, decision making, and so on. SNS is powerful and reliable for us to achieve our aim relatively in a short period. They are very useful and suitable to perform information sharing and exchanging in convenient ways. Figure 5 shows such human relation realized in SNS community such as in Campus network environment. Of course such a community may not be limited to local and/or domestic community in the same campus (College and/or University). It can be more widely spread and enlarged like SNS, for example, Facebook[205], Mixi[206] and/or Twitter[207].

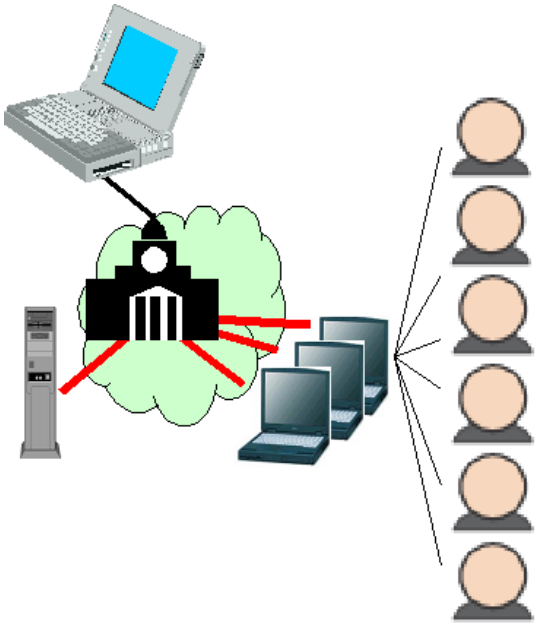


Figure 5: Establishment of Human Relation using Network Community.

If a user asks his colleagues in SNS community whether convenient resources exist close to them or not, some colleague replies his/her information about according resource. Of course, it is possible that others do not reply in a short period nor reply only they know nothing about such resources. Probably suitable resources will be found potentially in a short period through human relation established with SNS community. This is an example of "Resource Discovery through

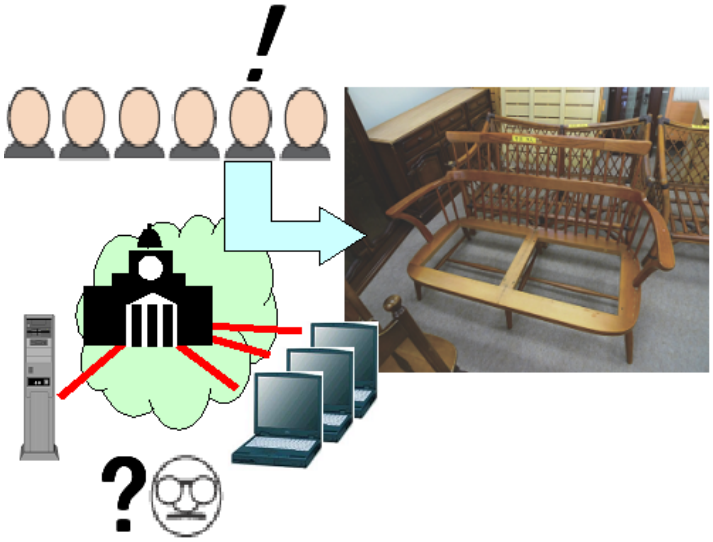


Figure 6: Resource Discovery in Network Community.

SNS community" shown in Figure 6. In the same manners, if a user wants to obtain some tools and know-how to re-produce furniture efficiently, he asks his colleagues, "Does anyone know where suitable tools are?" or "Does anyone have adequate information how to re-produce such kind of furniture?" This is also an example of "Knowledge Discovery through SNS community". Figure 7 shows that a user has obtained a necessary tool from Network Community and he(she) can use the relevant tool for Design Education in order to achieve his(her) purpose and/or target in a short period.

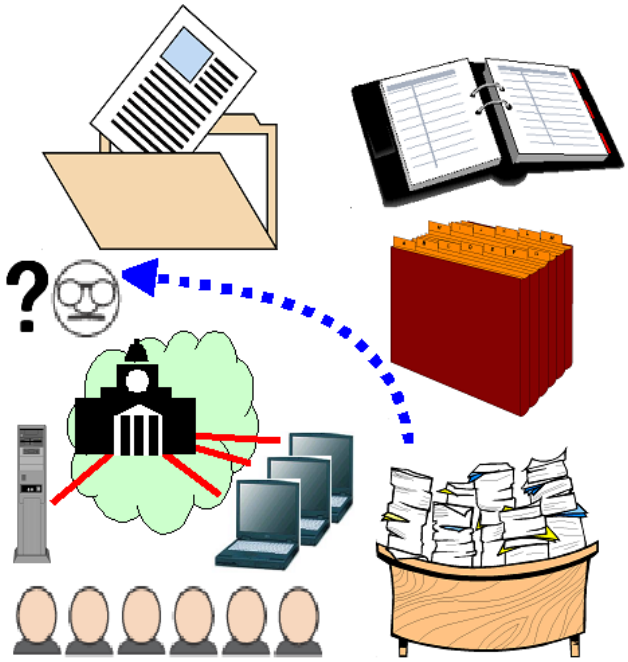


Figure 7: Knowledge Discovery in Network Community.

In the case of reproduction of furniture, it is very much necessary to find useful resources

efficiently. With utilization of Network Community, finding resources can be carried out more easily than others shown in Figure 6.

If a user is a beginner of our Proposal Design Education who cannot reproduce such a furniture by himself, he may want to know how to (re)produce good furniture with his resources. So he needs several kinds of knowledge to use resources and to handle tools effectively and efficiently. As you know, by means of Network Community, such a user may obtain suitable know-how to achieve his(her) purpose. He (She) can reproduce furniture with his(her) material discovered in Network Community by means of utilization of Know-How which can be also discovered in Network Community. Such a scheme is conceptually shown in Figure 7.

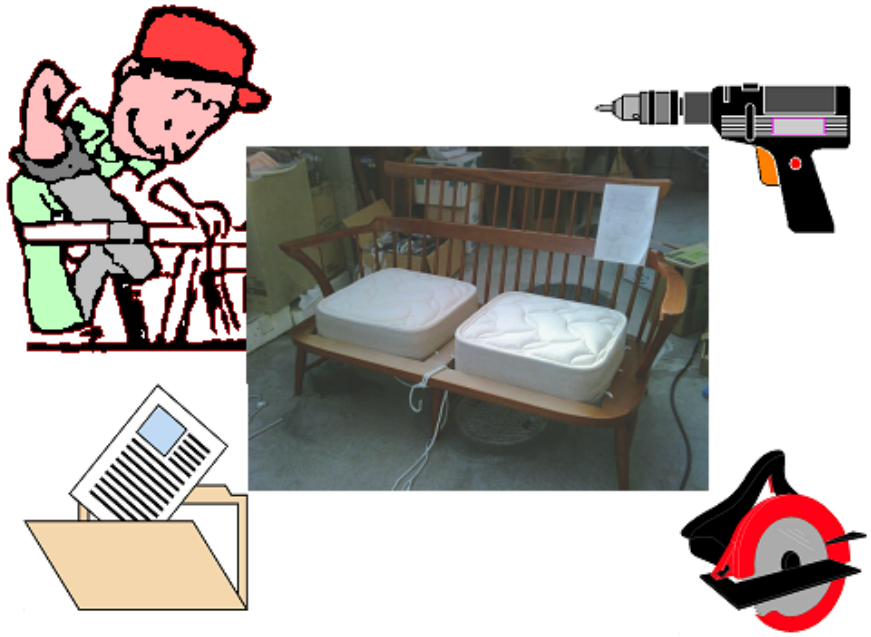


Figure 8: Reproducing Furniture by means of Tools and Knowledge using Obtained from Network Community.

Even a beginner of design education may sometimes be brought face-to-face with some related problems and then he(she) must retrieve/utilize Network Community and solve them using Such communities. In the case of reproduction of furniture as an example of design education, he(she) does really reproduce furniture with powerful supports from Network Communities. With help of good tools and suitable knowledge how to manipulate as well as timely discovered material, the relevant beginner can perform his(her) duty as his(her) task for design education to reproduce some kinds of furniture

Figure 8 shows that even a beginner can reproduce furniture by means of by means of tools

and knowledge discovered in Network Community. And he/she can accumulate not only all necessary techniques for tool manipulation but also knowledge about furniture reproduction through practical experience to use Network Community as well as to utilize resource, tool(s) and knowledge.

If needs are not very few, the next demands about furniture reproduction may occur potentially. Such demands are steady and continuous so that it may be necessary to prepare some market research and decrement of materials which are not only unused resources but also newly created ones.

2.8 Reproduction Qualitative Evaluation for Reproduction of Furniture as Recycling Resources

As evaluation of reproduction of furniture described above, we explain the following three items, namely cost-performance, feasibility study and human-relation based activity.

Cost-performance: Recycling of resources is positive but necessity to transport tools, resources and products is negative. The former is a good effect for ecology, cost-saving, and environmental protection. Resources for furniture are almost woods so their recycling can reduce some impacts from deforestation. Recycling also brings cost- saving normally. The latter is a bad effect for emissions of carbon dioxide through traffic increasing and all-too-easy way of borrowing tools and know-how. Emission of carbon dioxide must increase by means of transporting resources and tools. If an imprudent person wants to participate in such SNS community, he/she frequently raises troubles based on borrowing tools and know-how in easier ways than other conventional approaches.

Feasibility study: Our viewpoint for reproduction of furniture stands for the very best case to be performed. If some conditions are not satisfied, such reproduction cannot continue any more. For example, resources are necessary to be supplied in a low cost (although paying transport dues) and SNS community kindly provide know-how about relevant requests from users. In order to keep and satisfy the above conditions, we need to maintain and expand suitable human relation on SNS community. This may be one of most difficult problems!

Human-relation based activity: Utilization of SNS itself must be a good idea and it can be expected to make our life styles more fruitful. Although one person does not carry out

works, many persons can perform such works probabilistically. Namely, activities based on human relation will be identical to times of single person's activity. It may be expected to have synergistic effect based on human relation through our practical experiences. Anyway, it is necessary to lay out a well-suited goal to contribute to the maintenance of human relation on SNS community.

The above discussion has been limited to reproduction of furniture with recycling resources and tools/knowledge. But our concept may be applicable in other target of reproductive design education and finally suitable in practical design education schemes.

2.8.1 Quantitative Evaluation (PART I)

We have cordially asked 5 learners in reproductive design education to do feedback of correlation of themselves between their behaviors in SNS access and their corresponding satisfaction level based on utilization of SNS community for accomplishment during reproductive design education. This means whether it is useful for those 5 learners to get good satisfaction from Knowledge and/or Resource through SNS community for their practical reproductive design education. Table 1 shows the relevant result.

Table 1: SNS access times and Satisfaction level of 5 learners.

Name	Project 1		Project 2	
Learner ID	times*	level**	times*	level**
#01	2	2	3	4
#02	3	3	4	4
#03	5	4	5	5
#04	4	5	4	4
#05	2	2	3	2

(NB) times* =SNS access times, level** =Satisfaction level.

For example, as shown in Table 1, each learner receives two types of projects and his/her maximal access times for SNS is 5 and his/her satisfaction level is expressed from 1 to 5 (1: bad, 5: very satisfied). Table 2 shows correlation between access times of SNS by learner and satisfaction level.

This may have been the first evaluation about reproductive design education through SNS community, because the more times of SNS access are increasing, the higher level of satisfaction

Table 2: Correlation between SNS access times and Satisfaction level.

access	Satisfaction level				
times	1	2	3	4	5
1	0	0	0	0	0
2	0	2	0	0	0
3	0	0	2	1	0
4	0	0	0	2	1
5	0	0	0	1	1

is obtained by learner. So we have applied statistical analysis to Table 2 as the first quantitative evaluation for effectiveness of SNS utilization during reproductive design education. In order to confirm whether our approach can be significantly effective, we will perform chi-square test, namely χ^2-test for reduced version of Table 2, where the rows and columns contain all zero ' s are removed, as one of statistical analysis. The procedure is demonstrated as follows;

1. Calculating χ^2, namely

$$\chi^2 = (2-2*2/10)^2/(2*2/10) + (0-2*2/10)^2/(2*2/10) + \cdots + (1-2*2/10)^2/(2*2/10)$$

2. Obtaining $\chi^2 = 15.92$ from the above

3. Degree of freedom of Table 3 is $(4-1)*(4-1) = 9$

4. From χ^2-distribution table, we can get chi-square percentile with degree-of-freedom= 9 at the 5% significance level and 10% one as follows; $\chi^2_{\alpha=0.05}(9)$: $[\chi^2]$at 5% level with 9 degree of freedom = 16.9 and $\chi^2_{\alpha=0.10}(9)$: $[\chi^2]$at 10% level with 9 degree of freedom = 14.7, respectively.

In the above results of chi-square-testing, we can describe the following;

(a) If H_{01}: Scheme of our proposal is not useful at the 5% significance level ($\alpha = 0.05$) is a "null hypothesis", based on expression: $\chi^2 = 15.92 < \chi^2_{\alpha=0.05}(9) = 16.9$, at the 5% significance level, H_{01} cannot be rejected. Therefore, it can ' not ' be confirmed that Satisfaction level is dependent on SNS-access times. In other words, the former may be independent from the later, namely, utilization of SNS services is not significantly dependent on obtaining satisfaction of learners at the 5% significance level ($\alpha = 0.05$).

(b) However, if H_{02}: Scheme of our proposal is not useful at the significance level ($\alpha = 0.10$) is another "null hypothesis", based on expression: $\chi^2 = 15.92 > \chi^2_{\alpha=0.10}(9) = 14.7$, at the 10%

significance level, H_{02} can be surely rejected. Therefore, it can be confirmed that Satisfaction level is dependent on SNS-access times in this case. In other words, the former may be dependent on the later at the 5% significance level ($\alpha = 0.05$).

2.8.2 Quantitative Evaluation (PART II)

In order to investigate more precisely whether SNS-access times (namely, utilization of SNS services) are significantly dependent on obtaining satisfaction or not, after obtaining the above evaluation results, we have decided to carry out classroom-level questionnaire for larger numbers of learners at the end of design education. We have tried to evaluate quantitatively a scheme of our proposal through the second questionnaire again in order to obtain some certain eligibility of our proposal based on more scale of user size. Table 3 shows results of the above questionnaire.

Table 3: Another comparison of SNS access times and Satisfaction level for 15 learners.

Name	Total State	
Learner ID	times*+	level**
S01	4	5
S02	3	3
S03	4	4
S04	5	3
S05	5	4
S06	5	5
S07	4	4
S08	3	3
S09	3	2
S10	5	4
S11	5	5
S12	4	3
S13	5	5
S14	5	4
S15	5	5

(NB) times*+ =SNS access times (if 5 and more, learners are requested to express only ' 5 ' for convenient statistical analysis), level** =Satisfaction level.

Just like the same way as the previous analysis, we will demonstrate statistical analysis about the relation between utilization level of Knowledge/ Resource Discovery through SNS community and learner satisfaction level for our real Reproductive Design Education. Table 4 shows correlation between access times for SNS community and the relevant satisfaction level.

Based on Table 4, reduced correlation SNS access times and the relevant learners' Satisfaction level for Reproductive Design Education is described in Table 5 and its auxiliary parameters for

Table 4: Correlation between SNS access times and Satisfaction level for Table 3.

access	Satisfaction level				
times	1	2	3	4	5
1	0	0	0	0	0
2	0	0	0	0	0
3	0	1	2	0	0
4	0	0	1	2	1
5	0	0	1	3	4

statistical analysis are calculated and contained in Table 6.

The procedure of χ^2-test for Table 5 with Table 6 can be expressed below just like demonstration in the previous Quantitative Evaluation (PART I);

1. Calculating χ^2, using parameters in Table 6, namely $\chi^2 = (1-1*3/15)^2/(1*3/15) + (2-4*3/15)^2/(4*3/15) + (0-5*3/15)^2/(5*3/15) + (0-5*3/15)^2/(5*3/15) + \cdots + (4-5*8/15)^2/(5*8/15)$

2. Obtaining $\chi^2 = 14.72551$ from the above

3. Degree of freedom of Table 5 is $(3-1)*(4-1) = 6$, because of row=3 and column=4

4. From χ^2-distribution table, we can get chi- square percentile with degree-of-freedom= 6 at the 5% significance level as follows; $\chi^2_{\alpha=0.05}(6) = 12.5916$, namely $[\chi^2]$ at 5% level with 6 degree of freedom.

Table 5: Reduced Correlation between SNS access times and Satisfaction level for Table 4.

access	Satisfaction level					
times	2	3	4	5		subtotal
3	1	2	0	0		3
4	0	1	2	1		4
5	0	4	5	5		8
subtotal	1	4	5	5		15

Table 6: Auxiliary parameters for statistical analysis of Table 5.

access	Satisfaction level			
times	2	3	4	5
3	1*3/15	4*3/15	5*3/15	5*3/15
4	1*4/15	4*4/15	5*4/15	5*4/15
5	1*8/15	4*8/15	5*8/15	5*8/15

In the above results of chi-square-testing, we can describe the following; Assuming that H^+ [Satisfaction level of learners is independent from SNS-access times, namely utilizing SNS services] is a "null hypothesis", then it is demonstrated below: $\chi^2 = 14.72551 > \chi^2_{\alpha=0.05}(6) = 12.5916$, so that H^+ can be definitely rejected at the 5% significance level ($\alpha = 0.05$). Therefore, it can be surely confirmed that Satisfaction level of every learner is dependent on SNS-access times, namely, utilization of SNS services can be significantly dependent on obtaining satisfaction of learners. Our scheme of proposal for Reproductive Design Education is useful and effective for learners to perform Knowledge and Resource Discovery even at the 5% significance level ($\alpha = 0.05$).

3 Collaborative Design and its Evaluation through Kansei Engineering approach

3.1 Background of this section

In the world, Disaster Recovery (DR) has become one of the most important meanings and hopes of the people, especially in Japan after a terrible disaster attacked some East district of its country(namely it is called "Tohoku") on the 11th of March, 2011. DR must include very much several things and items, such as foods, medicines, jobs, many kinds of life lines, and residences. This paper focuses on proposal of residence recovery scheme for destroyed area by Huge Tsunami just like Tohoku.

One of the authors had a fortunate experience to visit Tohoku in 2010 and stayed a few days there to look at very peaceful scenes. An aim of visiting Tohoku was to watch several landscapes there in order to investigate what is suitable to build living spaces as residences for such circumstances, namely facing to the Pacific and standing behind mountains.

Normally, it is considered that flat area must be suitable to build traditional living spaces before huge tsunami attacked Tohoku on the 11th of March, 2011. After this disaster, however, it becomes unsafe and sometimes dangerous to build living spaces in flat area near the seashore. Frankly speaking, paradigm has been shifted (namely, quite changed) and it can be probably suitable to build some kind of living space for slope topography in order to avoid direct damages from tsunami.

Nevertheless, several kinds of people have no special knowledge and information about building of living spaces for slope topography. So they really wanted to obtain such knowledge and information from not only specialists but also real users who want to live at such spaces because of losing residences by tsunami and disasters.

More than 10 years ago, Jaime Solari described, in her Master Thesis[301] of Massachusetts Institute of Technology. Dept. of Civil and Environmental Engineering, it has been important to adopt concurrent design principles for architectural, engineering and construction projects and also necessary to have an important aspect of concurrent design for an effective communications infrastructure between team members.

This highly suggestive paper additionally pointed out "Such communication has been handled through person-to-person meetings, however the complexity of modern projects has grown and as a result, reliance on new information and communications technologies is becoming

increasingly necessary. Hence, within a concurrent design setting, there is the need for an integrated information and collaboration environment that will create a persistent shared workspace to support interaction between project personnel throughout all phases of the project."

Her thesis's research explored computer-supported mechanisms for enhancing distributed design collaboration and developed a set of requirements, system architecture and an early system prototype to facilitate computer-supported collaboration among distributed teams. Her prototype consisted of a persistent shared workspace system built from the integration of complementary collaborative applications.

Collaborative Design is one of the attractive, flexible and reasonable approaches to reach the temporal goal with help from related members and/or community in the relatively short period. Our research focuses on procedure for arranging or improving of residence through collaborative design methodology. One of key ideas is to utilize Social Network in order to achieve collaborative design. And other is to apply Kansei Engineering methodology to evaluation of procedure and decision making of results such a design has produced.

This paper includes introduction of collaborative design examples in the next section, prototyping and improving of collaboration in the third section, evaluation and improvement by Kansei engineering in the fourth section, and summarized conclusion in the final section.

3.2 Collaborative Design Approaches

3.2.1 Related Works

Paper[302] presents a gap between evaluation and constantly transforming work activities. Theoretical- methodological task of this paper is to apply theory of expansive learning as a learning approach to evaluation, linking evaluation and learning. The empirical case presented in the paper, analyzes a collaborative design process of a new type of evaluation tool. The paper suggests that theory of expansive learning and collectively created tools can be used for connecting two separate organizational worlds: constantly transforming activities and evaluation. The paper emphasizes that evaluation can be seen as collective, historical, dialectical, constantly transforming and developing activity.

Paper[303] pointed out, "Collaborative design is characterised by small-scale, carefully structured, professional design teams. The increasing popularity of social computing and mass communication supported by cyberworlds suggests there is now also a strong possibility of design through mass participation, beyond small-scale, collaborative design scenarios. However to

achieve collective intelligence design, there is a need to motivate large groups of users to contribute constructively to design tasks." This paper reviewed different types of cyberworlds to classify the motivation profiles of their user bases. It compared the above motivation profiles to those required for the emergence of collective intelligence and develop a list of technological requirements for cyberworlds to support collective intelligence and design.

Paper[304] described that intrinsic construction project nature of one-of-a-kind and the requirement of massive data exchange made collaboration one of the critical factors towards success. However, due to the complexity of multiple phases and multi-disciplinary participants in project life cycle, industry level collaboration in Architecture, Engineering, and Construction (AEC) sector remained a challenge. The paper proposed an integrated solution based mainly on social network services (SNS) and cloud computing. It presented a novel platform named Construction Business Social Network Service adopted as an industrial scope collaboration cloud.

3.2.2 Collaborative Design Concept

With combination of reviewing related works described before, the second half of this section explains our collaborative design concept to build and modify Living Space for Slope Topography.

Usually, they say that it is difficult to decide the most efficient and/or effective element(s) for the relevant users in a short period. Especially, only one or very few persons cannot resolve several problems which one evaluates positively but coincidentally another does negatively. Certain size of group can provide a lot of valuable ideas which can determine and adjust such problems into more acceptable solutions for wider range of human requests. Community-based approach will realize such valuable ideas and good design methodology.

Some people say Internet looks like one of huge communities. Of course, Internet itself provides loosely coupled human connectivity so that Internet users always want to have seamless access to LAN, WAN and/or global network in order to obtain several kinds of information, benefits, hints, idea and so on. But unfortunately Internet also includes a lot of evil-mind and ill-intention for a third party.

Whenever connected with Internet, its users have to confirm that information and/or ideas obtained from it are suitable and constructive for them at the glance. Therefore the users want to have not only access to Internet but also specific connectivity of Internet with trust and reliability. Social Network Systems in Internet, which is abbreviated as only SNS, can provide a suitable environment for us to be safe and comfortable in order to perform suitable collaboration

for work, evaluation and discussion[305].

One user of SNS can work together with his/her other members in order to communicate one another, exchange each information, and discuss about common problems asynchronously (i.e. not in realtime) but directly (almost without misreading). With connectivity of SNS, users can show their concept/solution, obtain efficient criticism about them from others, evaluate them among their community, and rebuild/modify original concept into more useful ones.

3.3 Prototyping of Collaboration

3.3.1 A Draft Scenario of Collaboration

First of all, this section illustrates a draft scenario of collaboration and implementation with SNS and then demonstrates an example of Collaborative Design[306] of living space for slope topography through Facebook as an example of SNS. An attempt has been carried out with utilization of Facebook as a efficient SNS of Internet Community.

The reason to employ Facebook as SNS is as follows;

- In Japan, there are some famous SNS for several kinds of users as Internet Community. But almost all are not so famous for foreign countries and also not so convenient for foreign users of Internet Community. Currently, Facebook has a huge numbers of members who belong to several countries and it seems to be one of the most powerful and influential SNS of the world.

- Even in the case of our personal experiences, Facebook is more effective and available for us to communicate with our friends and colleagues and exchange several kinds of information and idea by means of multimedia than others. Users of Facebook must enjoy easy handling of Information, multimedia and computer programming.

Figure9 shows a scheme for data distribution by means of Facebook. It shows that it is convenient for users to distribute original design and idea into their friends and colleagues through a function of Facebook asynchronously and directly. This user wants to proposes his idea and detail of design, transfer the relevant set of idea/design to his colleagues and realize information exchange with utilization of engineering drawing and photos of prototype.

With utilization of SNS, we will be able to expect some effects of Collaborative Design which realize a typical story as follows in Figure9;

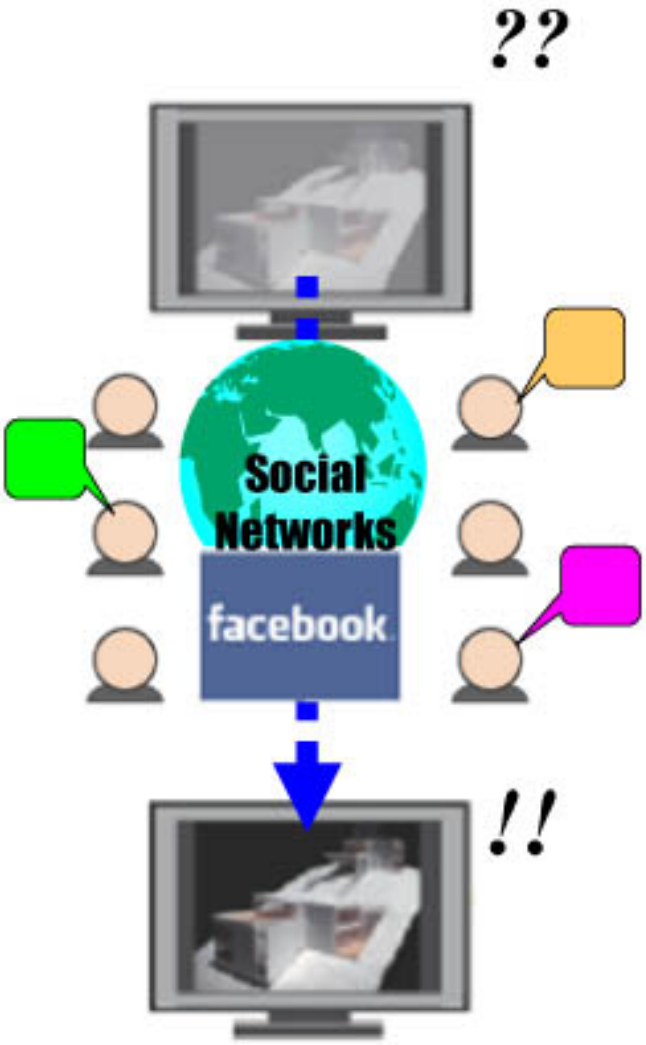


Figure 9: Collaborated Design among distributed Colleagues with utilization of benefit by Facebook

1. One of the relevant user's colleagues obtained an original idea through Facebook as Internet Community.

2. He/She thought about such idea and had some different idea and relevant comments for it.

3. He/She sent such different idea and his/her comments to the relevant user for convenience and modification.

4. The user obtained such useful idea and comments for the sake of his convenience and modification.

5. Finally, the user can rebuild his original idea and reconstruct design based on the more useful viewpoint.

With some benefits of Internet Community, we can prepare collaborative environment for efficient design methodology and discussion. We can expect direct communication with foreign colleagues although they are away from us and living in other countries. As the results of communication and discussion, we can obtain constructive comments, professional idea and criticism about our current problems asynchronously but smoothly. In the next subsection, we will demonstrate practical example of Collaborative Design for living space for slope topography through human connectivity of Facebook.

3.3.2 Example of Collaborative Design

We have been wanting to propose some specific idea to reconstruct residences as Living Space for Slope Topography, which are suitable particularly near the seashore for the sake of avoidance of Tsunami's damage potentially occurred in future. One of authors, namely Masatoshi Imai, has already had a lot of idea, design concept, and images of prototyping about living spaces and/or buildings for slope topography from his school days in his undergraduate course of university. But he is in domain of design field and not so familiar with practical architecture for building and construction.

So we have been expecting that colleagues discuss our original design concept, check and evaluate it and finally modify it into more fruitful one together with ourselves. Because it is very

Figure 10: Design Concept to Build Living Space for Slope Topography in Facebook.

nice for all people to live in such living spaces without fear about Tsunami, we want to discuss our initial idea and perform collaborative design through Facebook as a creative environment.

We will introduce a practical design concept to build living space for slope topography on multiple windows of Facebook shown in Figure10. The relevant design concept displayed in Figure10 can be realized and explained by means of several multimedia information such as engineering drawing, some views of prototyping and physical images for beginners and experts (professional engineers).

If someone has a glance at such URL, he/she can look at each information as precisely as he/she wants. In order to watch in detail, he/she can focus specific information, namely engineering drawing and/or three dimensional view of relevant building/living space. Figure11 is an example of engineering drawing for precisely reviewing. It may be suitable for professional users to recognize the detail of the relevant spaces. But it is not suitable for normal users or non-professional people to understand conceptual images for the relevant spaces. So we need to prepare another view for the relevant spaces. Figure12 is an example of three dimensional image which demonstrates other view as design concept. It can be suitable and attractive for normal users and/or non-professional people to obtain conceptual images graphically.

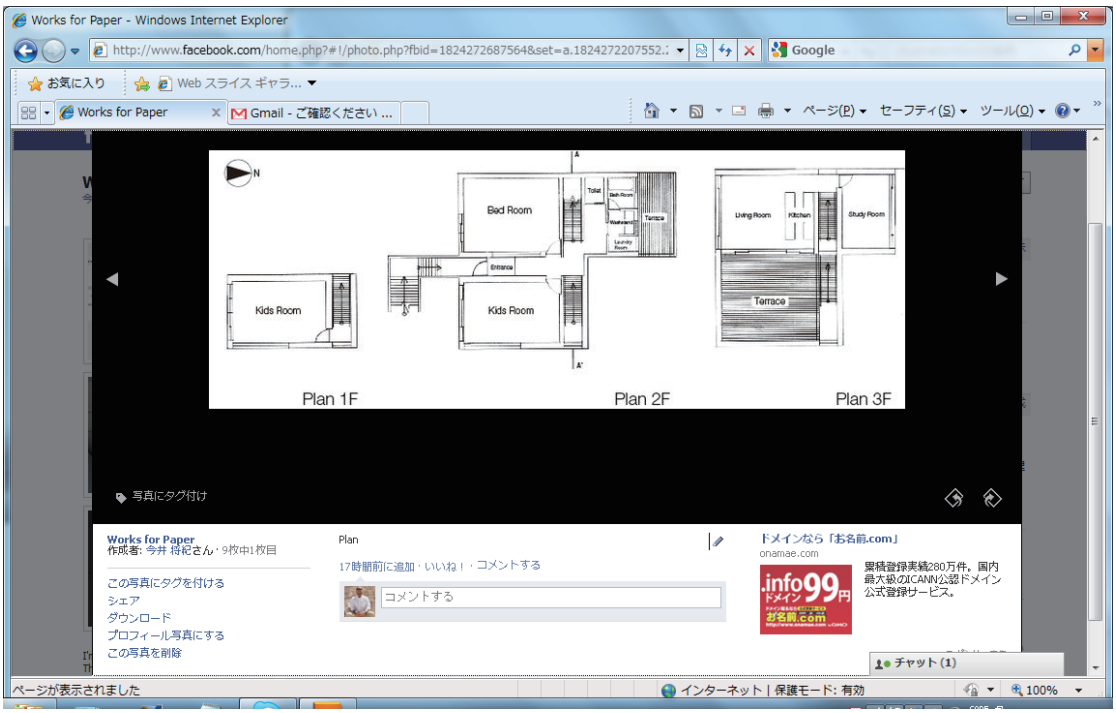


Figure 11: Sample Engineering Drawing as a Design Concept on FaceBook.

As described before, we are not professional engineers for architecture, so a chart of engineering drawing is not perfectly suitable to discuss our idea among professional engineers, but three

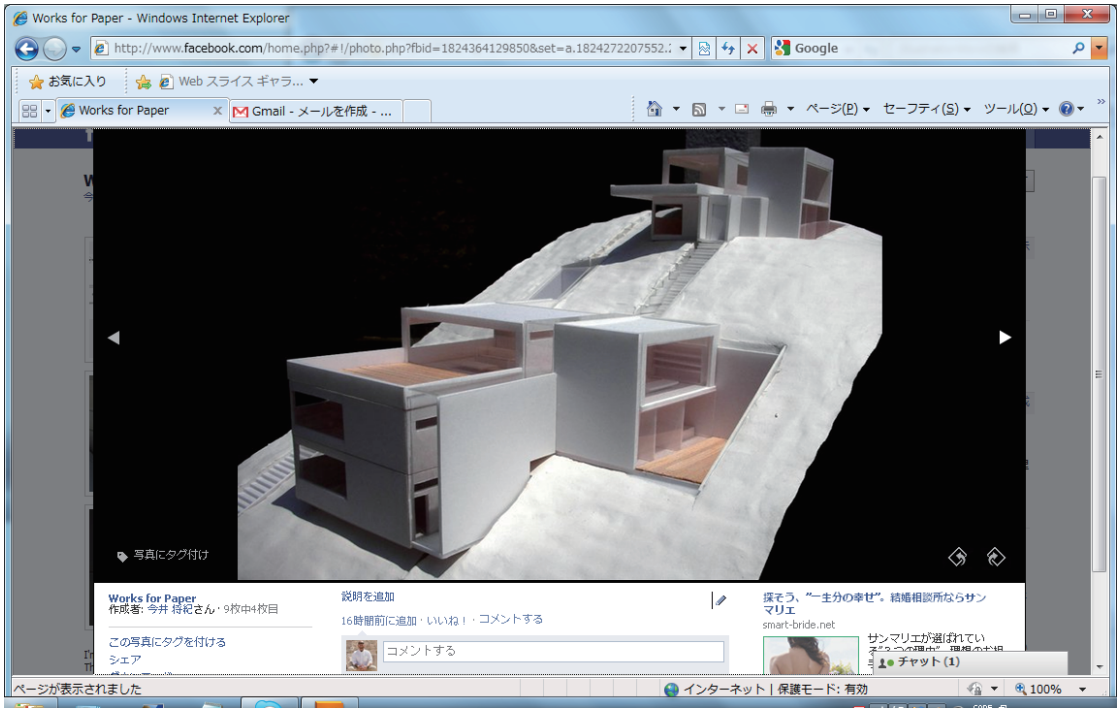


Figure 12: Sample Three-Dimensional View as a Design Concept on FaceBook.

dimensional image will be able to provide certain viewpoints even for non-professional persons. We want to receive some comments and criticism for our draft design proposal of living space for slope topography.

We think that beginners of architecture/landscape need some practical images in order to understand whether living space for slope topography is suitable or not even they want to avoid potential damage of disaster from Tsunami. So we have provided some three dimensional views of living space for slope topography and let the relevant people imagine as if they were living there more closely. Of course, we think that virtual reality and other visualization techniques are necessary for people who want to have more information about our idea. That must be another problem to be resolved by ourselves in future.

3.3.3 Web-based Acquisition of Information

Social Network is applicable and easily used for users to perform many kinds of information transmission and information exchanging among colleagues about the specific themes. Our collaborative design approach is also based on several effects from such social network as described in the before subsection. Although, for example, user interface of Facebook is well-designed for human operability, machine-based data manipulation is sometimes complicated and not so convenient for acquisition of information from colleagues on Facebook.

We have equipped Web-based acquisition facility to obtain information from such colleagues of network. Applicable information for our Web-based acquisition facility are supposed as follows;

- Discrete values:

  When users want to obtain pre-registered pattern of discrete values, it is suitable to utilize function of radio button as value input method of Web-based acquisition facility.

- Semi-Continuous values:

  When users want to obtain some range of continuous values, it is preferred to employ function of slide bar as value input method of our facility. In the case of using slide bar, boundary values, namely upper limit and lower one must be specified before.

- Freely specified values:

  When users want to obtain freely specified values, it is recommended to prepare function of input box as value input method of the facility. Because such a box can receive any kinds of string, not only numerical value but also text can be written inside of the box.

Our Web-based acquisition facility is easily implemented in usual Web server such as famous Apache software, other Web system and so on. Usage of Social network is suitable and best matched to Web system so that Social network services are working in collaboration with many usual Web servers. In order to acquire information from colleague efficiently, notation in Facebook includes the certain URL for some specific Web server which has provided Web-based information acquisition containing the above three kinds of value input methods. So colleagues can be easily introduced to the relevant acquisition facility of information. Such information has been input, processed and utilized just like as described in the next section.

3.4 Evaluation Process

3.4.1 Evaluation procedure by Kansei Engineering

As is known, Kansei Engineering[307] is one of efficient approaches to "translate users' psychological (emotional) feeling about a product/image into perceptual (machine-understandable) design element/methodology" for the sake of efficient realization[308]. Key idea to utilize Kansei Engineering for Collaborative Design is summarized as follows;

- One proposal may obtain a few comments and criticism which differ from one another. In such a case, we need smart strategy to accommodate the above comments and criticism for more suitable and allowable design, product, image and so on. Sometimes, comments and criticism are expressed in not quantitative but qualitative notation, so that we need some efficient mechanism to translate qualitative expression into qualitative one smoothly and suitably. Kansei Engineering is one of the most excellent methodologies to obtain quantitative (i.e. numerical and computer-oriented) parameters from psychological (emotional) expression or feeling.

- Kansei Engineering is one of the well-established methodologies founded in Japan and one of the most applicable procedures to analyze and classify multiple-parameterized input data, which sometimes differ from person to person even for the unified targets. In the world, Kansei Engineering is utilized from car manufacturing to fashion design and available in many kinds of domains which include not only engineering but also several kinds of decision making.

For example, in the case of discussion about window size of living space for slope topography, we want to decide whether height and width of window size is suitable for relevant height and width of according wall or not and to obtain information about parameter to enlarge or reduce the height and width of window against the fixed size of wall. For the sake of realization of Collaborative Design, the problem is how to get and find such parameterized requests in comments and criticism from colleagues of Internet Community.

3.4.2 Modification procedure by Kansei Engineering

We have employed Kansei Engineering approach and its powerful procedure of attribute rating. In order to determine whether size of window should be remained, enlarged or reduced and obtain its scale of parameterization for enlargement or reduction, we will apply the following steps;

1. preparing some questionnaire investigation with 5 stepwise graduations, namely, “enlarge more”, “enlarge a little”, “remain (or keep this size)”, “reduce a little”, and “reduce more”.

2. defining the maximal amplitude for enlargement and reduction.

3. comparing the result rating from the answer against questionnaire investigation with 5 stepwise graduations statistically.

4. calculating quantitative result with compared rating into the value from "enlarge more" to "reduce more".

5. mapping the above value into parameterized scale and get scaled amplitude to enlarge or reduce.

For example, we can define mapping function to translate emotional expression into rating of Kansei Engineering shown in "param."-column of Table7. Parameter 'f' with sign in this table means a factor to specify how to enlarge windows or reduce ones for the adjustment according to request from colleagues from Internet Community. Therefore, when the sign of 'f' is plus, we decide to choose an operation for enlarging of window. In contrast, when its sign is minus, we do for reducing of window. And absolute value of 'f' specifies amplitude of factor for level of enlarging/reducing. For example, the designers can employ not $f = 1.0$ but $f = 0.8$ as its value if they want not to adopt larger changes. Authors change the position of "param."-column in the below Table7 for the sake of more understanding of readers.

Table 7: Calculation of Parameterized Attribute with Emotional Expression from Internet Community

emotional ex.	P_1	P_2	P_3	P_4	P_5	param.	(subtotal)
enlarge more	$\surd$	-	-	-	-	$1.0f$	$1.0f$
enlarge a little	-	$\surd$	$\surd$	-	-	$0.5f$	$1.0f$
remain	-	-	-	$\surd$	-	(0.0)	$0.0f$
reduce a little	-	-	-	-	$\surd$	$-0.5f$	$-0.5f$
reduce more	-	-	-	-	-	$-1.0f$	$0.0f$

Table7 shows that there are 5 numbers of emotional expressions as comments or criticism from persons of Internet Community, namely from P_1 to P_5, and then we can try to calculate a parameterized attribute based on some criteria with such expression, which are demonstrated in the right side of Table7 and below numeral expression. And then we can obtain the precise factor to enlarge the relevant window by below calculation.

$$(1.0f + 1.0f + 0.0f + (-0.5f) + 0.0f)/5 = 0.3f$$

We can draw "enlargement of window by only 30% $\times f$ " from the above calculation in this example. Of course, 'f' can play a role for characteristic constant for original designers to adjust their final decision to operate. If the designers want to keep their original shape, they had better specify the real value of 'f' as small as possible.

Just like the above procedure, we can obtain other parameterized requests for Window's size as well as Window's position (namely, XY-position means Width and Height) and some suitable information for Collaborative Design among Internet Community. With Kansei Engineering methodology, we can determine which sensory attributes express particular subjective requests and draw conclusion about which perceptual elements are responsible to enhance emotional decision, for example in Figure13. This figure visually shows Window's position, namely width/height, is approximately the same as original one (denoting blue line "standard") and Window's size is requested to be more larger than original one (denoting red line "param"). It is convenient for us to realize Collaborative Design based on Internet Community precisely and reasonably.

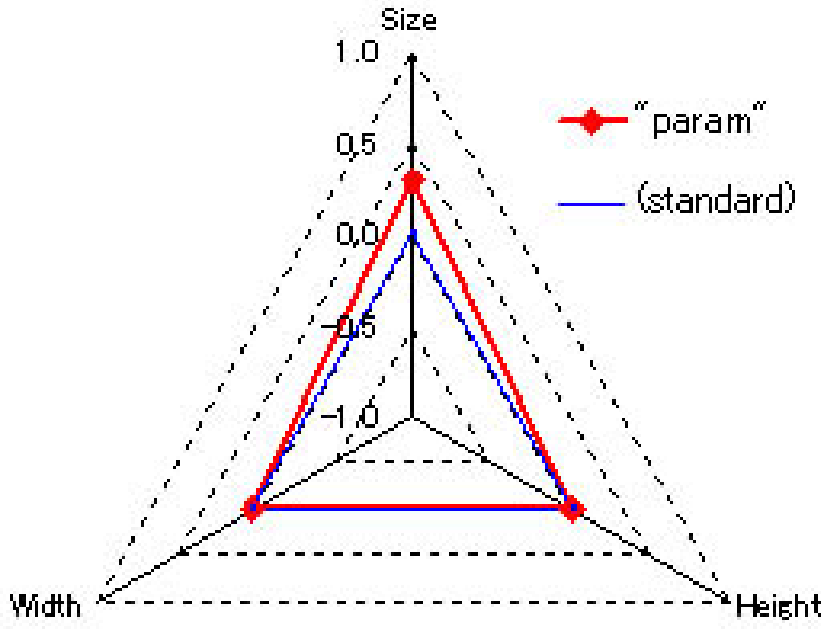


Figure 13: Radar Chart of Parameters' Value for Improvement.

Authors had participated in a project to apply Kansei & Human Engineering to Architectural Design and obtained good experience from that project study. And they have submitted their another Kansei Engineering-based research named "A Scheme of Resource Discovery in Reproductive Design Education" into other international conference [309].

4 Kansei Engineering-enhanced Collaborative Design of Promotion Poster

4.1 Background of this section

People say that design process sometimes needs many complicated and time-consuming procedures. One of its solutions is to perform practical designing through collaboration by support of registered members, namely advantage of collaborative design. There are several articles about collaborative design to realize suitable procedure and environment for its effective accomplishment. Solutions need how to provide information sharing effectively among the related members and how to perform decision making efficiently by the members. Social networking system (SNS) seems to be one of powerful tools to realize information sharing and communicating. And Kansei engineering used to be one of the well-known approaches to accomplish reasonable and strategic decision making.

With our previously developed information server for Web application, our system has been tailored into information-sharing and decision-making support one to realize network-based smart community like domain-oriented SNS for collaborative design effectively and efficiently in a relatively short period. In order to build large-scale poster for college promotion and the publicity of entrance examination, we have taken some photos for candidates of poster, put them on exhibition with our information sharing system, shared them with the determining committee's members on the system, and helped such members perform decision making smoothly together with our system.

This paper reports our approach to perform collaborative design not only enhanced by Kansei engineering but also facilitated by a newly developed information-sharing and decision-making support system. The paper also illustrates how to apply our design collaboration scheme into large-scale poster building as a practical example of design process.

The next section of this paper describes our related works of collaborative design and ones of Kansei Engineering-based design. Its third section introduces and illustrates the outline of our information sharing and decision making support system and its detail facilities for design and collaboration. The fourth section demonstrates the real design process of collaboration enhanced by Kansei engineering to build up the poster for college promotion by means of information sharing and decision making support system. The last section summarizes our conclusion and the future problems to be resolved finally.

4.2 System Configuration

This section explains our background of design concept, overview of our system, main procedure of the system and topical functions of proposed system.

4.2.1 Background of Design Concept for new Services

Many users who already belong to some kind of affiliation such as enterprise, university, society and so on frequently access the SNS and obtain several opportunities to perform information sharing and exchanging in a real world. We have facilitated Kansei engineering for the sake of our designing and evaluating in a few years[401]. That was a very exciting and creative experience for us and we have had many fruitful results. And Kansei engineering is a powerful scheme/solution to perform useful decision making in order to conduct feasible results and conclusion. A lot of product design have been employing Kansei Engineering for its decision making. We have had such very similar experience to utilize SNS in order to achieve collaborative design in a few years[402].

In this case, we have some restrict conditions to build and/or use our information sharing and decision making support system for collaborative design as follows;

1. System must provide effective services to let relevant documents to be recorded automatically in order for any third parties to perform Follow-Up Survey of information sharing and decision making and to verify the relevant process by such parties efficiently.

2. The process of information sharing and decision making should be definitely closed and exclusively accomplished among restrict members due to the mission of collaborative design of promotion poster building. Dedicated system is necessary in order for us not to employ general purpose SNS facilities but to realize special purpose information sharing and decision making support system.

3. System utilize Kansei Engineering-based approach for speed-up and good performance of decision making, equip built-in questionnaire service for efficient choosing and voting against proposed candidates from system manager and/or committee for the sake of process enhancement of information sharing and decision making.

Because of the above discussion, we have decide to build up our system for collaborative design of college promotion poster not with major SNS but by ourselves without usage of Open

famous SNS just like Facebook. That is our necessary condition to build up our information sharing decision making support system.

4.2.2 Overview of System

System must be equipped to provide information sharing services whose objects are not only text but also binary files such as images, documents/spreadsheets, and other application working files. In such a case, a Web-based system, for example, *PukiWiki*, *GitLab* and related domain-limited information sharing system, will be suitable for our necessary condition, that is campus-oriented and limited access for security-based usage. Simultaneously, the system must be equipped to perform some kind of communicating environment just like SNS for casting their votes for or against the target proposed draft. In such a case, another Web-based system, for example, small-scaled groupware and related application, will be suitable for another kind of necessary condition.

Figure 14: Campus-based Information sharing and Decision making support system.

System employs combination of Web-based Information server and its some kinds of clients which are from potable note PCs to tablets/smart phones. The system configuration is based

on the result requested from a lot of members of committee who want to use their personal communicative devices in side of college definitely. Figure 14 shows an overview of our campus-based information sharing and decision making support system.

4.2.3 Main Procedures of System

The following procedures have played very important roles in the case of design collaboration for poster building. The former is to provide poster foundation for registered members, to carry out questionnaire for them and to receive their results efficiently through information sharing service, which is realized server-client Web application subsystem. The latter is to compute Kansei Engineering methodology for effective and measurable decision making performed with the comments, opinions and many types of evaluation from the registered members.

Figure 15 shows the main flow of "Kansei Engineering enhanced Collaborative Design". In our case, Kansei Engineering methodology has mainly consisted of analysis of questionnaire based on 5-point Semantic Differential scale and calculation of evaluated values from the registered members based on Quantification Theory, which has been a powerful evaluation method to introduce some kinds of direction, relation and design/decision rules for design specifications. Many useful researches and their excellent papers[403][404][405][406] had kindly taught that Semantic Differential method and Quantification Theory had been playing dominant roles in Kansei Engineering.

"Selection" procedure of Figure 15 shows any users some candidates from the system and collects comments/answers from the registered users. "Kansei engineering" procedure obtains users' answers based on 5-point Semantic Differential scale, calculates the relevant values evaluated by users based on Quantification Theory, and generates graphical results for users. "Choosing & Voting" procedure carries out questionnaire for users and tally up their results leading to possible determination. "Process Recording" procedure memorizes and accumulates the final situation and the process for possible and suitable determination into storage for the sake of trace checking by the third party. Our system employs Kansei Engineering method to enhance collaborative design through effective decision making by means of realization of the specific procedures shown in Figure 15.

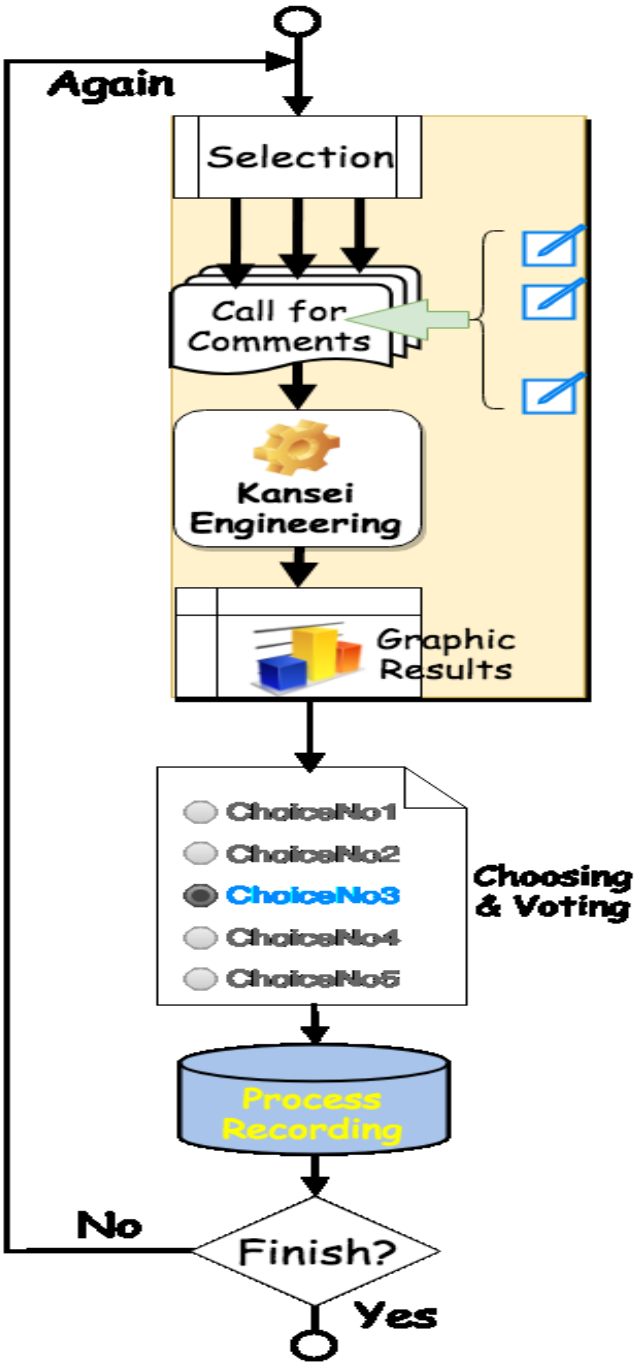


Figure 15: Kansei Engineering enhanced Collaboration

4.2.4 Functions Proposed by System

Our system can provide the following functions in order for the users to accomplish collaborative design.

1. **File viewing and exchanging**: Users of the system can view the registered types of files by means of suitable application on their browsers. Users sometimes want to modify a

relevant file in order to show their opinion to others. In such a case, they view the relevant file and send request to "exchange the file" into system.

2. **Report generation based on evaluation by Kansei Engineering**: System asks some categories of questionnaire to obtain summary count. After that, it can analyze the answers from users at the proposed questionnaire, evaluate such a result by means of Kansei Engineering approach, and finally generate some kinds of reports for users to understand trends of answers for the proposed questionnaire.

3. **Casting vote for or again the proposed object**: The users want to assert their opinions for the proposed objects and/or targets. Vote casting is one of the most popular behaviors which can determine whether they turn thumb up or down on the relevant proposal. System carries out different types of questionnaire and it can provide graphic results of vote casting.

4. **Question asking for system manager**: Unfortunately, our experience has shown that system sometimes does treat with its some special user kindly or disappointingly. In such case, the relevant user wants the system manager to look a notice of that situation. So system must have a special communication channel with high priority between manager and the registered users independently.

4.3 Design Process of Collaboration

This section demonstrates initiation of our system, design process with system ' s facilities and how to perform decision making through our system.

4.3.1 Initiation of the System

In the case of this research, our target is some kinds of suitable photos of the college building and the relevant aim is to choose the most suitable one of the building photos for the promotion of the college, especially for entrance examination promoting poster. The period for photo choosing and the relevant poster design is very much short and tight, while such a process for design and decision making must be complicated and tough to accomplish the final consensual understanding in an expected period. We have decided to apply our information server and Web application into information sharing and decision making support system for design collaboration due to the above tough mission.

With the information sharing and decision making support system, users who have been previously registered can post their comments and view the target objects (= candidate photo and poster files) by means of personal devices with the registered IP-address. The system manager can initiate the system and put an original idea and/or objects on the suitable potion and set the relevant attribute for the original one. The other users of the system can view the original one and sometimes put their comments and criticism for the target on the column of the system, which is prepared by the manager for the sake of communicating. Such comments and criticisms can be evaluated among all the users. In other words, viewing results have been classified and enumerated into choosing-or-voting calculation so they are to be added into the newly feedback evaluation for the relevant target. And then all the users including the current manager can decide whether the target should be fixed(or accepted) or modified(request of alternative shape/form/model or rejected) according the results from the previous user ' s evaluation.

One of the authors plays a role to take several photos for candidates of poster foundation. And they must perform the initiation of system, namely preparing some photos for candidates and proposal of not final version of poster foundation. Figure 16 shows the original poster foundation with simple footer and sign of campaign message on the right hand of the photo.

Figure 16: Original poster with simple footer.

But those are not decorated, because of receiving comments and criticism from the committee members.

The system will be set up for committee members(registered users) to receive the information-sharing service to view the candidates, check the design process, choose one of the candidates and finally vote each evaluation for the candidates of the poster. The committee members are including the president of the college, executive officer, and so on. As well known, they are always very busy and have probably no or very little time to attend such a special meeting to perform poster design and obtain consensual decision. So we need and have to provide suitable environment for asynchronous communication between the above committee members.

4.4 Collaboration based on Facilities

With system facilities, the registered members of the Committee can view the original figure of poster foundation at first, write many comments, choose favorite one by their skills and senses, questions and criticisms for candidates, and finally cast their votes for or against the target proposed draft. In this case, target draft is the original figure, which is given on the system as a candidate of poster foundation material. Committee members request the draft of poster to include more detailed information about the college because it is used for entrance promotion in the outside of college, for example, at the station or public place. So in the next stage of the poster design, the new draft patterns are requested to provide more detailed information in the footer description. Figure 17 shows two alternative of newly modified patterns of draft poster including detailed information.

Figure 17: Footer description to provide more detailed information: (left) and (right).

The upper of Figure 17 shows a modified version of the draft poster foundation of Figure 16 with footer description. And the lower of Figure 17 shows an alternative pattern of poster foundation with different photo of the college building. Against Figure 17, some members of committee request to change color of right-hand message of the draft poster from Red to White, while others request to change photo image of the draft poster from Zoom-in to Zoom-out. Our system has memorized that members of committee had pointed out that people who looked at both of Figure 16 and the upper of Figure 17 could not find the entrance gate and hole of the college. They thought that both draft poster Figure 16 and the upper of Figure 17 were not suitable for the entrance promotion of their (namely our) college. It was very important for them to perform such step-by-step information sharing and decision making on the system asynchronously and explicitly.

Collaborative design process should propose two types of alternatives for he upper of Figure 17 with the different photo of the college building shown in the upper and lower of Figure 18.

In order to discuss the contents of poster, one of the system managers proposes that footer of the poster had better include URL of the college so that the more newly draft of poster is modified as shown in Figure 19. For users of information system it is very natural to employ the notation of URL on the document for people to access quickly. But some members of committee may be different type from system users so that they do not agree with employment of the notation of URL on some kind of documents because they think the area of this type of document (poster) is too limited to add unnecessary notation. It is very funny but really feasible to discuss on the system in order to conduct feasible results and conclusion.

Figure 18: Two types of alternatives for the upper of Fig.17 with the different photo of the college building: (left) and (right).

Another opinion from one member of committee is a little unique. His proposal is that the photo of college inside is better than one of college outside, because students, who look at the relevant poster shown in Figure 20, may be able to imagine easily and feel friendly they would be "in our college" (namely, they would be already a student of our college!). Such discussions are sometimes very interesting but at the same time they are going around and around for a long time. So it is necessary to decide by vote casting among the members of committee with relevant function of our system. Generally speaking, a part of collaborative design process has time-consuming and unnecessary proposing/discussing periods probably. System managers point to a trend of considering it something to avoid, but members of collaborative design seem to be very important and essential for decision making.

Figure 19: Footer including URL of college.

Figure 20: Photo of college inside.

4.4.1 Decision Making on the System

It is very much important for collaborative design process to perform decision making by such a reasonable way that all the constituent members can fully understand and accept the relevant situation. Functions of our information sharing and communicating system provide reasonable decision making service with weighted vote casting by means of adding suitable weight as priority order of each constituent member. Therefore, a rule that the president of the college has the first priority of vote casting gain approval from all the constituent members. That is a very realistic approach to perform the final decision making for collaborative design of practical objects.

Kansei Engineering can play an important role to evaluate feasibly opinions and comments

from members of collaborative design. It can provide numerical criteria to classify comments and proposals. So other members easily understand and perceive whether each opinion, comment and/or proposal is worth to be discuss or not. And at the same time the relevant member himself/herself who did say opinion, comment, and/or proposal can recognize how it has been considered concretely.

Figure 21 shows Web-based user interface of our information sharing, communicating and decision making system, which has been designed and preliminarily implemented with Simple Web server just like LAMP + PukiWuki based server and JavaScript for client (= user side). It can provide Web-based exhibition of contents such as comments, question (=questionnaire) and candidate (=photo) and then obtain the answers/comments from members through its user interface.

This time, the final poster of entrance promotion of the college has been now set at the nearest station of our college. It is one of the evidence that our information sharing and communicating system can play a role to support collaborative design of practical problem. And it is confirmed

Figure 21: User Interface of Campus-based Information sharing and communication system.

that the system is useful for the relevant members to view the proposed draft, exchange their comments, opinions and criticism, and finally cast their votes for the sake of decision making in a way the member can accept the situation.

5 A Scheme to Carry out Questionnaire in order to Evaluate Product Design and its Level of Excellence

5.1 Background of this section

Previously, Japan used to pay national interest based attention to product performance explicitly rather than product design. People thought that the latter would hardly depend on "external" appearance combined with shape and color, while the former could be at the root of industrial technologies. Many of them might believe that product design was too superficial so that it was less important than product performance which encompassed a lot of things such as mechanism, methods, materials and know-hows.

Recently, the authors have become aware of an importance of product design and its values not only for attraction based on "external" appearance but also for its artistic values and strategic meanings. Moreover the authors need suitable environment for design education in order to realize effective instruction and teaching of product design. Such an environment has been necessary at industrial and technological domains as well as other educational ones.

The authors have developed our Web-based Questionnaire system with Linux, Web server(by Node.js or Python), PHP and Javascript for design education. This paper describes a scheme to carry out questionnaire for learners of design education in order to evaluate product design and its level of excellence and practical design process by means of utilizing the questionnaire system. It explains system configuration and functions provided by system for questionnaire in the next section, illustrates practical example of carrying out Web-based questionnaire for design education in the third section, and summarizes conclusion and perspective in the last section.

5.2 Detail of System

This section explains system configuration and functions provided by system for questionnaire.

5.3 System Configuration

The authors have developed a new questionnaire system on the base of Linux, a typical web server such as Apache, Node.js or Python-based one, and application code written by PHP and Javascript. Figure 22 shows a whole schematic conceptual image, namely system configuration, of our Web-based Questionnaire System.

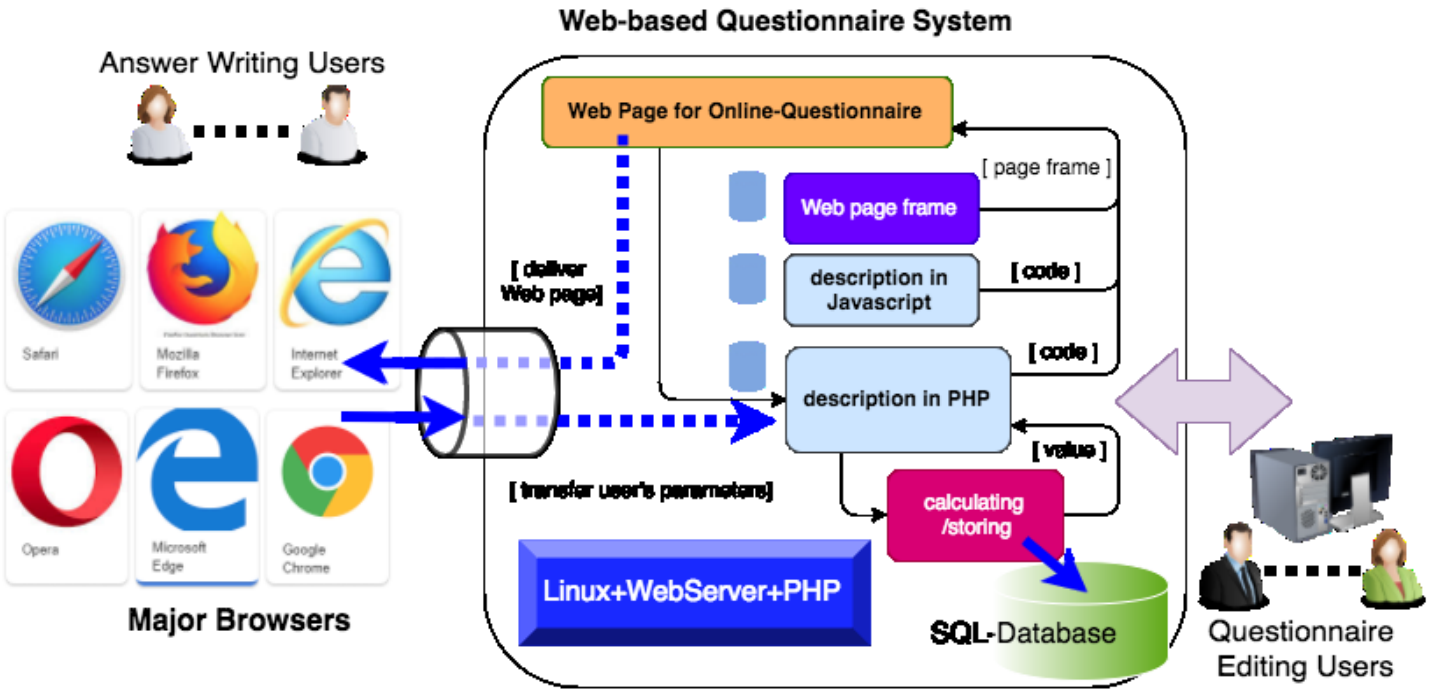


Figure 22: System Configuration of Web-based Questionnaire System.

System includes following submodules; Lunix, web server, PHP interpreter and SQL database as one package, so-called LAMP or LAPP, code description in PHP, code description in Javascript, and Web page frame to carry out simple online questionnaire for education.

1. OS: Lunix or Windows, Web Server: Apache, Node.js or Python-based simple HttpServer, PHP, and SQL DB; These are BaseGround as package for our system. And a lot of Linux server can provide the above environment usually for any users. The authors have decided to implement our system on such a very popular environment for the sake of easy prototyping.

2. Code Description in PHP: initialization, receipt of user specified parameters, calculation of values from users, and data storage into Database; PHP is a very suitable language interpreter to write procedure working on the above base ground easily and to provide powerful services for Web application. Its application code includes initializing Web page and receiving input data from user who answered questionnaire. It also serves calculating the values from users and save them into SQL Database.

3. Code Description in Javascript: working on users' browsers, drawing User interface there, transfer the input data by users into Mother server; Code of Javascript has been transferred from the Mother system shown in Figure 22 and executed by Javascript engine built-in

on the browser. It can work as user interface between users (on browsers) and system (questionnaire system which can manipulate data, calculate them and store the results).

4. Our system can demonstrate twofold roles not only to provide editing questionnaire but also to carry out questionnaire, namely answering it. In the former case, system supports "questionnaire editing users" to construct and/or modify questionnaire before it is carried out. In the latter case, system supports "answer writing users" to answer or reply each question of questionnaire carried out by system.

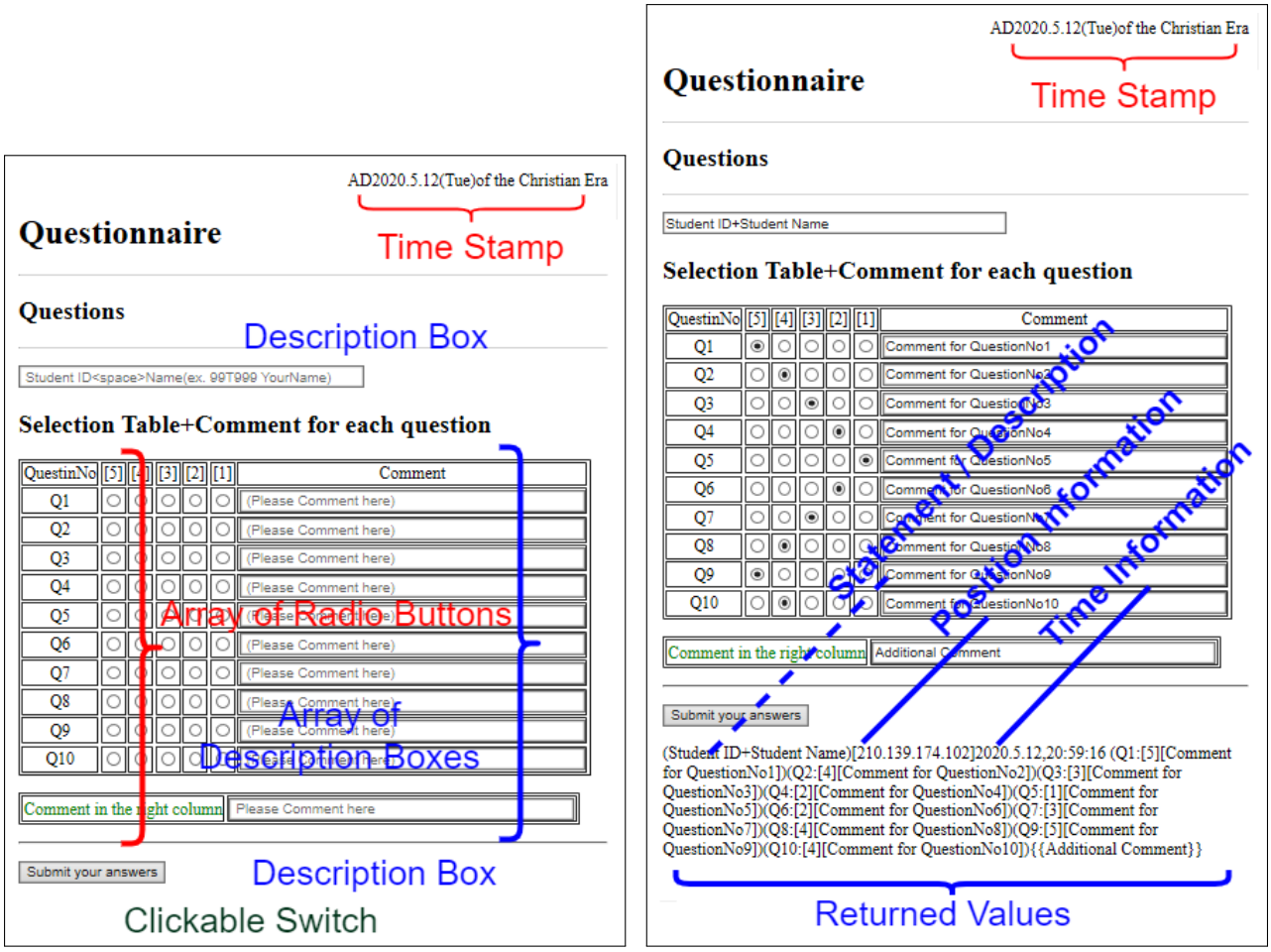
With the above submodules, our system has been very tightly and efficiently developed and relatively easily modified for several applications including questionnaire and online testing. And the system possess higher reliability so that it can provide better performance for the purpose at educational environment.

5.3.1 Web Page Manipulation

Online questionnaire is to be carried out in the following steps. And Figure 23 shows two types of Web pages for questionnaire, namely its left, Fig.23(a), is an initial page before a user write the values, and its right, Fig.23(b), is another one, which has been already sent after some user wrote the values in order to answer. From Figure 22, it is well-defined that

1. System prepares some framework of Webpage and adds some information to the blank page. Such information include time stamp, description box, array of radio buttons and clickable switch. If questionnaire editing users want to customize the numbers and/or layout of the above elements for their own specification, they can modify code description in Javascript. For example, one of the typical structure with the above elements can be recognized on the display of browser shown in Figure 23(a).

2. Answer writing users are asked to answer some questionnaire from questionnaire editing users. Answer writing users can write their answers using description box and array of radio button and then re-send their results of answers by click action with clickable switch. They can recognize their own results below of clickable switch. The relevant results have been sent to the mother server as each message line. Such a message line will be constructed with Statement / Description written in the description box, returned values selected on the array of radio bottoms and the following added information. Such information includes



(a) Initial page before values are input

(b) Sent page after values have been input

Figure 23: Two Web Pages for Questionnaire.

position information corresponding IP address, time information corresponding just time of transferring message and so on. For example, one of the typical structure with above answer results with such information can be also recognized on the display of browser shown in Figure 23(b).

3. By means of time information and position information included in message line which can be received in the mother server, questionnaire editing users can obtain several useful data as the answer results from answer writing users for the preparing questionnaire. For example, questionnaire editing users can notice some information about answer writing users such as where they answer and when they do. because position information based on IP address and time information can teach questionnaire editing users where answer writing users replied questionnaire and when they did explicitly. And moreover it will be able to be calculated what time it did take for each answer writing user to reply his/her answer result(s) from the difference time between time stamp and time information.

System can support questionnaire editing users as well as answer writing users by means of the above Web page manipulation. It can provide basic environment to carry out online questionnaire efficiently and effectively,

5.4 Practical Application

This section describes what is questionnaire online, and illustrates our practical application of the system into carrying out questionnaire about poster selection. Questionnaire of poster selection has been carried out in the following orders described in the next subsections.

5.4.1 What is online Questionnaire

People would like to carry out questionnaire for some kinds of selection, when they want to obtain adequate decision in the case of selection from the relevant candidates. They prepare such candidates before carrying out questionnaire. Previously, people used to put a notice on a bulletin board before carrying out questionnaire in order for others to perform smooth selection objectively. Recently, people are coming to use Internet and Network-based Communication, so that scheme of notice on a bulletin board has been replaced with Web-based exhibition. And they want to use convenient "Online, namely Web-based" questionnaire system together with the above Web-based exhibition.

Based on our definition described in the previous section, at first, people who want to carry out Web-based questionnaire have to prepare some kind of notices which used to be placed on a bulletin board, and currently prepare or editing Web Page by means of the relevant candidates for suitable notice. They will be defined as, namely called "Questionnaire Editing Users". Secondarily, others, namely other people except of "Questionnaire Editing Users" who are asked/requested to select their adequate candidate among other ones have to write their answers for the above questionnaire. They will be defined as, namely called "Answer Writing Users".

5.4.2 Posting Candidates for Questionnaire

"Questionnaire Editing Users" prepare contents of Web pages just like as people used to do a notice on the board. This time, "Questionnaire Editing Users" have designed and created some candidates of real posters to be employed as the official poster for the conference. And they have to post their candidate ones on the Web site for suitable selection of the official one to

Figure 24: Poster Candidate for Questionnaire

be accepted kindly and efficiently by the potential participants of the conference. It is not a joke, but the authors want to deal with how to select suitable poster by means of carrying out questionnaire in this case.

Figure 24 illustrates that "Questionnaire Editing Users" have posted their relevant posters on their Web page before their carrying out questionnaire in order to select the adequate poster for the potential participants of the conference. Recently, the authors have ever experienced great advances of performance on computing power and communication speed. Especially, mobile devices, so-called smartphones, have got a lots of benefits from both of the above advanced performance. So the authors can easily and smoothly obtained very fine and precised images for the poster from the mother server which will have carried out the related questionnaire.

Not only PCs but also smartphones can provide high-resolution display which facilitates zooming up and zooming own very easily. Such environment will be very much suitable for "Answer Writing Users" to check the candidates of posters, to evaluate their level for candidate and to select, namely decide to vote their best one for given problem, questionnaire.

5.4.3 Carrying out Questionnaire for selection

Our questionnaire has been carried out in the following procedures, namely preparing materials, posting them on the Web page(s), editing the contents for questionnaire, posting/publishing the relevant Web page for questionnaire, being requested to write their answers for questionnaire and finally receiving/obtaining the answered results from "Answer Writing Users". Figure 25

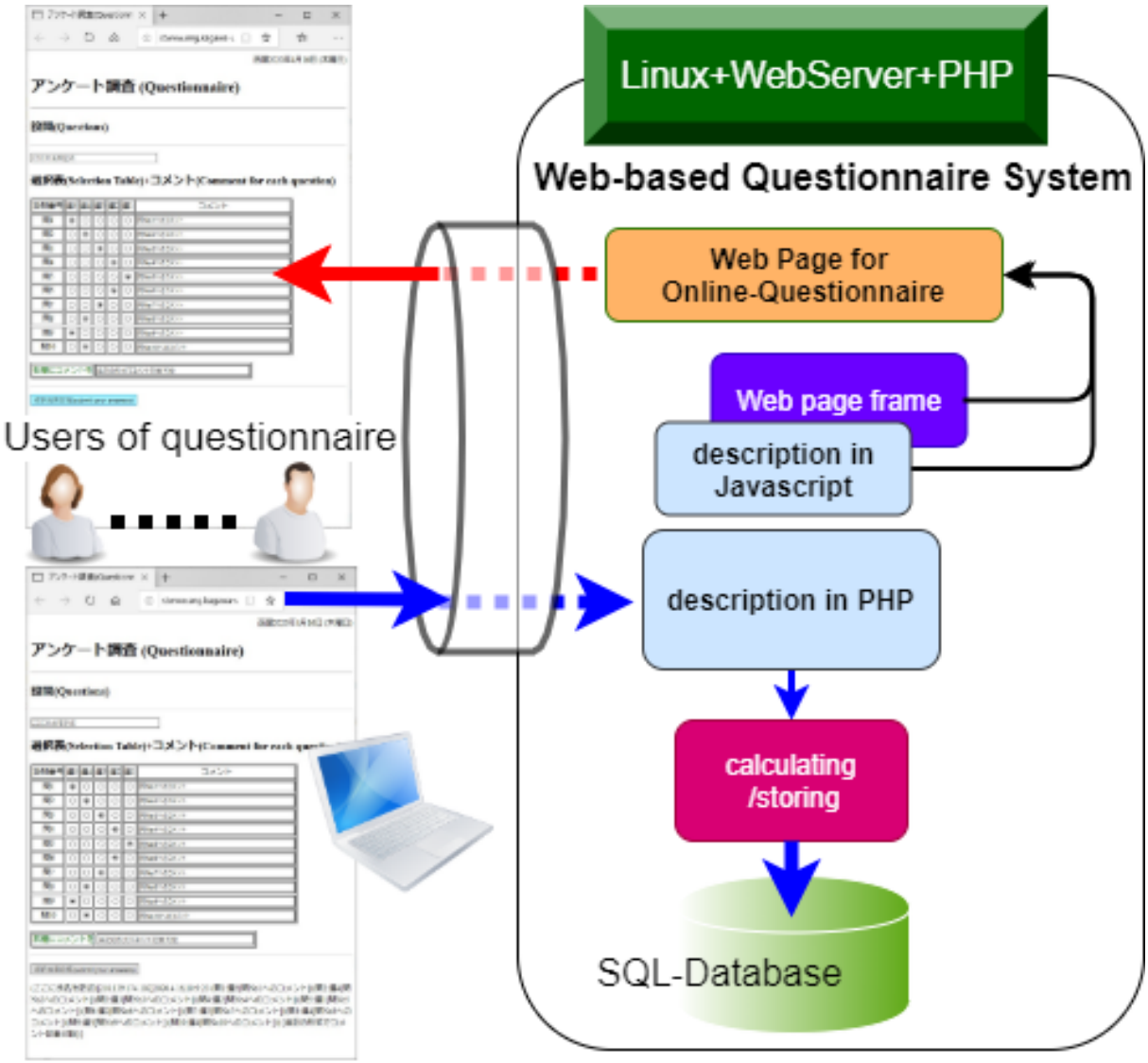


Figure 25: Page Flow to carry out Questionnaire

shows a typical page flow to carry out questionnaire.

1. **Preparing materials and Posting them on the Web page** by someone who asked "Questionnaire Editing Users" to carry out questionnaire : This process must be done exactly before carrying out questionnaire. Someone who ask "Questionnaire Editing Users" can be probably different from "Questionnaire Editing Users" or can be the identical to "Questionnaire Editing Users".

2. **Editing the contents for questionnaire**: This process also have to be terminated before carrying out questionnaire. And the process almost always should be demonstrated by "Questionnaire Editing Users". It seem to be the same of process which seems to be illustrated in Figure 24.

3. **Posting/Publishing the relevant Web page for questionnaire**: Figure **??** shows the upper half of it and illustrates such performance by means of Left-direction 'Red-colored' arrow. This process is also to be performed by "Questionnaire Editing Users" on the server side.

4. **Being requested to write answers for questionnaire**: This process is executed by "Answer Writing Users" explicitly on the client sides. Answered results will be transferred from the browsers of many clients into the mother server.

5. **Receiving/Obtaining the answered results from "Answer Writing Users"**: Figure 25 shows the lower half of it and illustrates such performance by means of Right-direction 'Blue-colored' arrow. This process is again to be performed by "Questionnaire Editing Users" on the server side.

6. **Calculating the answered results by Analyzing Engine and Storing the necessary values into Database**: Figure 25 shows calculating and storing modules from PHP code to SQL-Database and illustrates such performance by means of down-direction 'Blue-colored' arrow. Answered results and values from "Answer Writing Users" are saved into database carefully and they can be called back from database and may be sometimes utilized for the sake of analysis of the results of questionnaire.

5.5 Collaborative Design Process

This section demonstrates practical design process based on collaboration. Design target is to build a suitable poster for the participants of the international conference. Such design process has been realized together with Web-based questionnaire.

(a) the updated version of the previous poster (b) the hot favorite of the conference poster

Figure 26: First Two types of Posters.

5.5.1 Initial Condition

The conference normally needs public relation to draw the attention of potential participant. So authors used to be requested to build a suitable poster of the conference in order to have an attention of people who will potentially participate in the conference. Previously, authors had ever designed some posters and CD jackets for the conference, so they already recognized what kind of images will be interested by the previous participants and what type of styles can draw attentions of such participants.

One of their candidate posters is almost similar of the previous one, because of its good evaluation not only by the previous participants but also by some of conference local steering

members. Authors had prepared only updated version of the previous poster with new date when this year's conference will be held at the same location. They have understood that the suitable reference model must be necessary for people to compare with it and decide to be the best among some candidates. So-called objective selection actually needs not only the hot favorite but also some rival candidates.

Figure 26 shows two types of posters, Fig.26(a) is the updated version of the previous poster which displays one of the old style Japanese building with two-floors, called "Shoukou Shorei Kan" in the Ritsurin National Garden, and Fig.26(b) is clearly the different type of the previous one the authors have newly designed as it were the hot favorite which displays one of the three large bridges across the Seto Naikai inland sea, named "Seto Oohashi". Actually, the previous version of Fig.26(a) had been the official poster of the previous conference and many participants wanted to bring the relevant posters and flags to their returning (see the Figure 27).

Figure 27: Official posters of Previous conference.

5.5.2 Comparison with favorite and rival candidate

The most effective comparison with the hot favorite and other rival candidates had better be performed in the objective decision by many numbers of election. Carrying out questionnaire for evaluation of candidate posters is one of the most objective methods to determine the useful and adequate one among the given numbers of possible candidates. The following answers and

recommendations have been confirmed from the results of questionnaire: (1) The poster of this year must be changed, namely different from the previous one. (2) "Ritsurin Garden" is good, but "Seto Oohashi" is also good and suitable for not only Kagawa but also Shikoku/Japan, therefore the poster of this year had better employ the latter rather than the former. As the results of the first questionnaire, Fig.26(b) has been seemed as one of the hottest favorite of this year for the official poster.

5.5.3 Necessity of other candidates

The authors had received another recommendation from some answers of the previous questionnaire. They pointed out that "Selecting one from the two" might be not so suitable for questionnaire, especially for objective questionnaire, so "Questionnaire Editing Users" had better provide more numbers of candidates than the previous two. On the behalf of "Questionnaire Editing Users", one of the authors has provided the following other two types of candidates for poster due to the above considerable answers.

Figure 28 shows another two types of posters, Fig.28(a) is the third candidate of the conference poster and Fig.28(b) is the fourth candidate of the conference poster. The former has been designed with the specific landscape of Peninsula of Takamatsu pref. called "Yashima" and summer clouds as a motif, while the latter has been designed with olive tree and fruits which has been a Kagawa Prefectural tree and very much famous fruit all over the world.

5.6 Analysis of the results from questionnaire

The authors have carried out the second time questionnaire for selection of the official poster with Fig.28(a) and Fig.28(b). One half of the answered results from questionnaire has been similar with what the authors have already expected, but another half of them has been different from those, namely unexpected for the authors. Typically answered results are as follows; (i) Many Japanese like Fig.28(b) rather than Fig.28(a), probably because "Olive" seems to be a symbol of Green and Peace, (ii) Some of foreign researchers, especially European, pointed out that Japanese conference had better employ Japan-original motif and texture. It might be that Olive was very popular in Europe so designing with olive could not be worthy of the poster of Japanese conference.

From the total results of questionnaire, the authors have determined the following final decision; (1) Fig.26(b) is one of the hot favorite rather than Fig.26(a) although the previous

(a) the third candidate of the conference poster

(b) the fourth candidate of the conference poster

Figure 28: Second Two types of Posters.

version of Fig.26(a) and Fig.27 had been evaluated very nice and worthy of bringing the flag back to returning by the last participants. (2) Fig.28(a) cannot have obtained so big evaluation from "Answer Writing Users" due to the relevant answers of questionnaire. (3) Fig.28(b) is good for Japanese, but it is not so good for foreign researcher who used to participate in the previous conference. (4) As putting the above results together, namely taking them into consideration, the authors, on the behalf of "Questionnaire Editing Users", have decided to select Fig.26(b) as the official poster design.

6 Confirmation of Quantitative Evaluation for Product Design

6.1 Background of this section

Collaborative design is a good approach to obtain useful and practical results with colleagues in a relatively short period. Our focused problem is to build the large scale poster for college promotion and the publicity of entrance examination, whose mission is important so we need good performance and accountability in the process of collaboration for product design supported by Kansei Engineering, because of its capability and fruitful achievement. As many times of decision making may be performed through design process, traceability is important to validate consistency of decision making toward design results. We decided to employ Kansei Engineering to realize good performance of collaborative design and to apply it to Web system for decision-making. This paper describes the detail of our approach how to perform collaborative design through our Web system and how to demonstrate confirmation of consistency in evaluating product design based on collaboration by means of Analytic Hierarchy Process (AHP) methodology.

6.2 Related Works

Stefan Wiltschnig and his co-researchers from Copenhagen Business School reported, in their paper[601], "Creative design concepts are often viewed as developing iteratively, with the design problem and solutions 'co-evolving' in a mutually adaptive manner." They said a study examining whether the co-evolution concept captures the creativity arising in collaborative, team-based design practice. "The analysis revealed that co-evolution episodes occurred regularly and embodied various directional transitions between problem and solution spaces. Co-evolution episodes linked with other creative activities such as analogising and mental simulation and there was a clear association between co-evolution and expressions of epistemic uncertainty." Their findings supported the view that co-evolution is the ' engine ' of creativity in collaborative design. *It is a good and reasonable idea to perform collaborative product design in iteratively developing manner with the design problem and solutions 'co-evolving'. We have employed our facilities of design collaboration process for iteratively developing manner.*

Enar Nordvik of Luleå University of Technology, Sweden and his co-researchers described, in their paper[404], "The research strategy involved showing digital pictures of the same room, but with different wood flooring. The impressions of potential consumers were measured by means of

rating scales for each descriptive word. This was done using the method of Kansei engineering, in which statistical connections between properties and semantics (descriptions) were analyzed. Using statistical methods, Kansei engineering can provide a mathematical connection between emotions evoked by a product and physical properties. The result is just a snap sketch?traits and items could change. With Kansei engineering, it is possible to predict, relatively quickly, how people experience different wood traits and to determine what wood properties obtained from pictures, when combined, result in a high score among the affective value words." *We agree this relevant direction of this study and have referred to its useful approach, namely using Kansei Engineering to obtain the evaluation and to do decision-making for competing products.*

Yuan Xue and her co-researchers from Nara Women ' s University, Japan reported, in their paper[405], "In this study, sixty Wacoal bras were regarded as stimuli. The survey was conducted by using Semantic Differential method, which was a typical method of Kansei engineering. Fifteen pairs of adjectives and four pairs of phases on color, pattern, style, preference were selected to prepare the questionnaire. Firstly, the respondents ' impressions were obtained from the basic statistic, and the impression comparison between any two stimuli could also be obtained. Then, the emotion space of these bras was carried out by performing the factor analysis. Finally, the corresponding relationship between each stimulus and emotion factor was obtained by performing the cluster analysis." *It is very useful to employ Semantic Differential method and to carry out related questionnaire for impression comparison and cluster analysis.*

6.3 Required Specifications for our System

Many users who already belong to some kind of affiliation such as enterprise, university, society and so on frequently access the SNS and obtain several opportunities to perform information sharing and exchanging in a real world. And Kansei Engineering is a powerful scheme/solution to perform decision making in order to conduct feasible results and conclusion. A lot of product design have been employing Kansei Engineering for its decision making.

In this case, we have some restrict conditions to build and/or use our information sharing and decision making support system for collaborative design as follows;

1. System must provide effective services to let relevant documents be automatically recorded in order for any third parties to perform Follow-Up Survey of information sharing and decision making and to verify the relevant process.

2. The process of information sharing and decision making should be definitely closed and exclusively accomplished among restrict members due to the mission of collaborative design of promotion poster building. Dedicated system is necessary in order for us not to employ general purpose SNS facilities.

3. System utilizes Kansei Engineering-based approach for speed-up and good performance of decision making and provides built-in questionnaire service for efficient choosing and voting against proposed candidates from system manager and/or committee.

Because of the above discussion, we have decide to build up our system for collaborative design of college promotion poster by ourselves without usage of Open famous SNS just like Facebook. That is our necessary condition to build up our information sharing and decision making support system.

6.4 System Configuration

System must be equipped to provide information sharing services whose objects are not only text but also binary files such as images, documents/spreadsheets, and other application working files. In such a case, a Web system and related domain-limited information sharing system, will be suitable for our necessary condition, that is campus-oriented and limited access for security-based usage. Simultaneously, the system must be equipped to perform some kind of communicating environment just like SNS for casting their votes for or against the target proposed draft.

6.4.1 Main Procedures of System

In our case, Kansei Engineering procedure has mainly consisted of analysis of questionnaire based on 5-point Semantic Differential scale and calculation of evaluated values from the registered members based on Quantification Theory, which has been a powerful evaluation method to introduce some kinds of direction, relation and design/decision rules for design specifications. Many useful researches and their excellent papers [403][404][405][406] had kindly taught that Semantic Differential method and Quantification Theory had been playing dominant roles in Kansei Engineering.

The following procedures have played very important roles in the case of design collaboration for poster building. The former is to provide poster foundation for registered members, to carry out questionnaire for them and to receive their results efficiently through information sharing

service, which is realized server-client Web application subsystem. The latter is to compute Kansei Engineering methodology for effective and measurable decision making performed with the comments, opinions and many types of evaluation from the registered members. Figure 15 shows the main flow of "Kansei Engineering enhanced Collaborative Design". "Selection" procedure of Fig.15 provides some candidates from the system to the registered users and collects comments/answers from such users. "Kansei Engineering" procedure obtains users' answers based on 5-point Semantic Differential scale, calculates the relevant values evaluated by users based on Quantification Theory, and generates graphical results for users. "Choosing & Voting" procedure carries out questionnaire for users and tally up their results leading to possible determination. "Process Recording" procedure memorizes and accumulates the final situation and the process for possible and suitable determination into storage for the sake of trace checking by the third party. Our system employs Kansei Engineering method to enhance collaborative design through effective decision making by means of realization of the specific procedures shown in Fig.15.

6.4.2 Functions provided in System

Our system can provide the following functions in order for the users to accomplish collaborative design.

1. **File viewing and exchanging**: Users of the system can view the registered types of files by means of suitable application on their browsers. Users sometimes want to modify a relevant file in order to show their opinion to others. In such a case, they view the relevant file and send request to "exchange the file" into system.

2. **Report generation based on evaluation by Kansei Engineering**: System asks some categories of questionnaire to obtain summary count. After that, it can analyze the answers from users at the proposed questionnaire, evaluate such a result by means of Kansei Engineering approach, and finally generate some kinds of reports for users to understand trends of answers for the proposed questionnaire.

3. **Casting vote for or against the proposed object**: The users want to assert their opinions for the proposed objects and/or targets. Vote casting is one of the most popular behaviors which can determine whether they turn thumb up or down on the relevant proposal. System carries out different types of questionnaire and it can provide graphic

results of vote casting.

6.5 Collaborative Design Process

This section demonstrates initiation of our system, design process with system ' s facilities and how to perform decision making through our system.

6.5.1 System Initiation

In the case of this research, our target is some kinds of suitable photos of the college building and the relevant aim is to choose the most suitable one of the building photos for the promotion of the college, especially for entrance examination promoting poster. The period for photo choosing and the relevant poster design is very much short and tight, while such a process for design and decision making must be complicated and tough to accomplish the final consensual understanding in an expected period. We have decided to apply our information server and Web application into information sharing and decision making support system for design collaboration due to the above tough mission.

With the information sharing and decision making support system, users who have been previously registered can post their comments and view the target objects (= candidate photo and poster files) by means of personal devices with the registered IP-address. The system manager can initiate the system and put an original idea and/or objects on the suitable potion and set the relevant attribute for the original one. The other users of the system can view the original one and sometimes put their comments and criticism for the target on the column of the system, which is prepared by the manager for the sake of communicating. Such comments and criticisms can be evaluated among all the users. In other words, viewing results have been classified and enumerated into choosing-or-voting calculation so they are to be added into the newly feedback evaluation for the relevant target. And then all the users including the current manager can decide whether the target should be fixed(or accepted) or modified(request of alternative shape/form/model or rejected) according the results from the previous user ' s evaluation.

One of the authors plays a role to take several photos for candidates of poster foundation. And they must perform the initiation of system, namely preparing some photos for candidates and proposal of not final version of poster foundation. Figure 16 shows the original poster foundation with simple footer and sign of campaign message on the right hand of the photo.

But those are not decorated, because of receiving comments and criticism from the committee members.

The system will be set up for committee members (registered users) to receive the information-sharing service to view the candidates, check the design process, choose one of the candidates and finally vote each evaluation for the candidates of the poster. The committee members are including the president of the college, executive officer, and so on. As well known, they are always very busy and have probably no or very little time to attend such a special meeting to perform poster design and obtain consensual decision. So we need and have to provide suitable environment for asynchronous communication between the above committee members.

6.5.2 A collaboration based on System Facilities

With system facilities, the registered users of the Committee can view the original figure of poster foundation at first, write many comments, choose favorite one by their skills and senses, questions and criticisms for candidates, and finally cast their votes for or against the target proposed draft. In this case, target draft is the original figure, which is given on the system as a candidate of poster foundation material. Committee members request the draft of poster to include more detailed information about the college because it is used for entrance promotion in the outside of college, for example, at the station or public place. So in the next stage of the poster design, the new draft patterns are requested to provide more detailed information in the footer description. Figure 17 shows two alternative of newly modified patterns of draft poster including detailed information.

The upper of Fig.29 shows a modified version of the draft poster foundation of Fig.16 with footer description. And the lower of Fig.29 shows an alternative pattern of poster foundation with different photo of the college building. Against Fig.29, some members of committee request to change color of right-hand message of the draft poster from Red to White, while others request to change photo image of the draft poster from Zoom-in to Zoom-out. Our system has memorized that members of committee had pointed out that people who looked at both of Fig.16 and the upper of Fig.29 could not find the entrance gate and hole of the college. They thought that both draft poster Fig.16 and the upper of Fig.29 were not suitable for the entrance promotion of their (namely our) college. It was very important for them to perform such step-by-step information sharing and decision making on the system asynchronously and explicitly.

Collaborative design process should propose two types of alternatives for the upper of Fig.29

Figure 29: Footer description to provide more detailed information: (upper) and (lower).

with the different photo of the college building shown in the upper and lower of Fig.30. In order to discuss the contents of poster, one of the system managers proposes that footer of the poster had better include URL of the college so that the more newly draft of poster is modified as shown in Fig.19. For users of information system it is very natural to employ the notation of

URL on the document for people to access quickly. But some members of committee may be different type from system users so that they do not agree with employment of the notation of URL on some kind of documents because they think the area of this type of document (poster) is too limited to add unnecessary notation. It is very funny but really feasible to discuss on the system in order to conduct feasible results and conclusion.

Another opinion from one member of committee is a little unique. His proposal is that the photo of college inside is better than one of college outside, because students, who look at the relevant poster shown in Fig.20, may be able to imagine easily and feel friendly they would be "in our college" (namely, they would be already a student of our college!). Such discussions are sometimes very interesting but at the same time they are going around and around for a long time. So it is necessary to decide by vote casting among the members of committee with relevant function of our system. Generally speaking, a part of collaborative design process has time-consuming and unnecessary proposing/discussing periods. System managers point to a trend of considering it something to avoid, but members of collaborative design seem to be very important and essential for decision making.

6.6 Decision Making on the System

It is very much important for collaborative design process to perform decision making by such a reasonable way that all the constituent members can fully understand and accept the relevant situation. Functions of our information sharing and communicating system provide reasonable decision making service with weighted vote casting by means of adding suitable weight as priority order of each constituent member. Therefore, a rule that the president of the college has the first priority of vote casting gain approval from all the constituent members. That is a very realistic approach to perform the final decision making for collaborative design of practical objects.

Kansei Engineering can play an important role to evaluate feasibly opinions and comments from members of collaborative design. It can provide numerical criteria to classify comments and proposals. So other members easily understand and perceive whether each opinion, comment and/or proposal is worth to be discussed or not. And at the same time the relevant member himself/herself who did say opinion, comment, and/or proposal can recognize how it has been considered concretely.

Figure 31 shows Web-based information sharing and questionnaire system. The left-hand of Fig.31 is user interface of our Web system and its right-hand is main part of our system for

Figure 30: Two types of alternatives for the upper of Fig.29 with the different photo of the college building: (upper) and (lower).

information sharing, decision making and questionnaire supporting, which has been designed and preliminarily implemented with LAMP, PukiWiki for the server side and JavaScript, PHP for user side. It can provide Web-based exhibition of contents such as comments, question

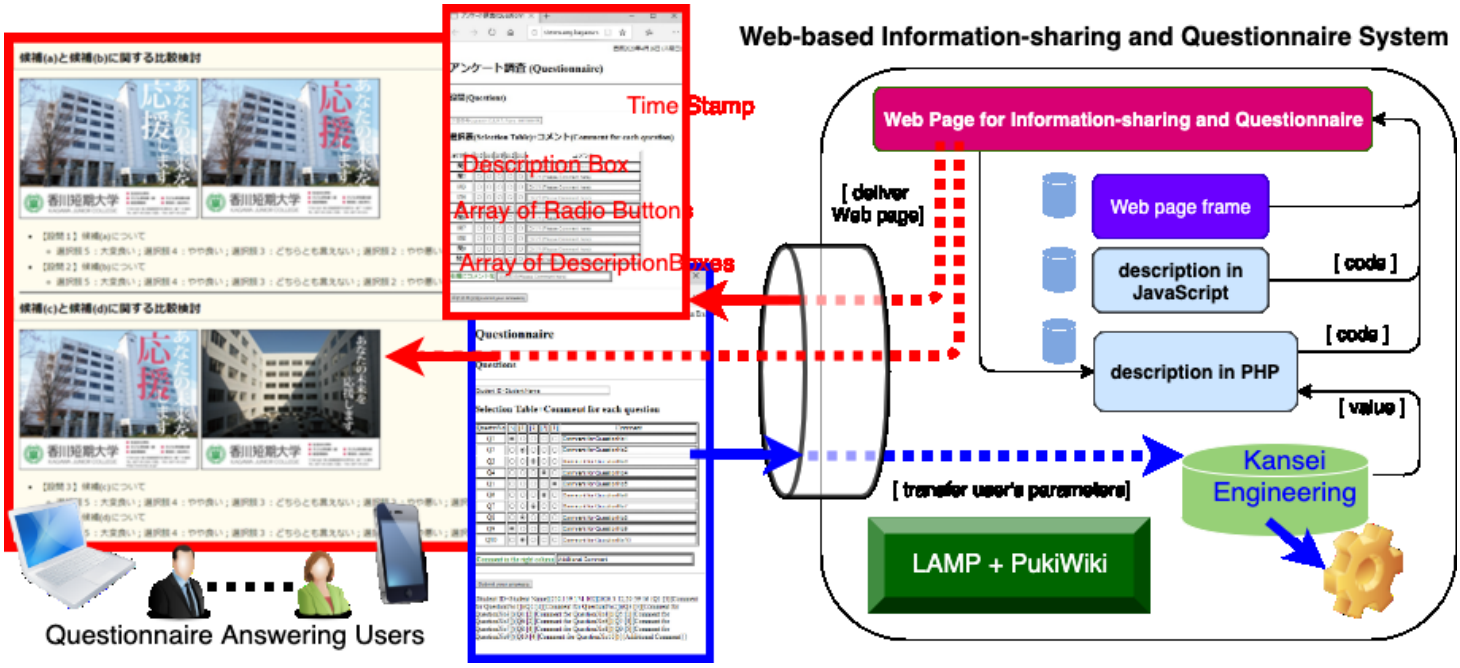


Figure 31: Our Web-based Information sharing and questionnaire system.

(=questionnaire) and candidate (=photo) and then obtain the answers/comments from members, namely Questionnaire Answering Users, through its user interface. This time, the final poster of entrance promotion of the college has been now set at the nearest station of our college. It is one of the evidence that our information sharing and questionnaire system can play a role to support collaborative design of practical poster design problem [603]. And it is confirmed that the system is useful for the relevant members to view the proposed draft, to exchange their comments, opinions and criticism, and finally to cast their votes for the sake of decision making in a way the members can accept the situation.

6.7 Confirmation of Design Results by AHP

This section confirms that our Kansei Engineering-based approach and its results of product design have been reasonable and acceptable through another quantitative evaluation.

6.7.1 Traceability and Confirmation

Mutual understanding is one of bases for collaboration, so information sharing is one of the most essential facilities our system must provide. Traceability is also important for collaboration. It is sometimes necessary and should be objectively verifiable to explain what have brought such design results to us.

Our Web system can provide decision making supported by Kansei Engineering. Figure

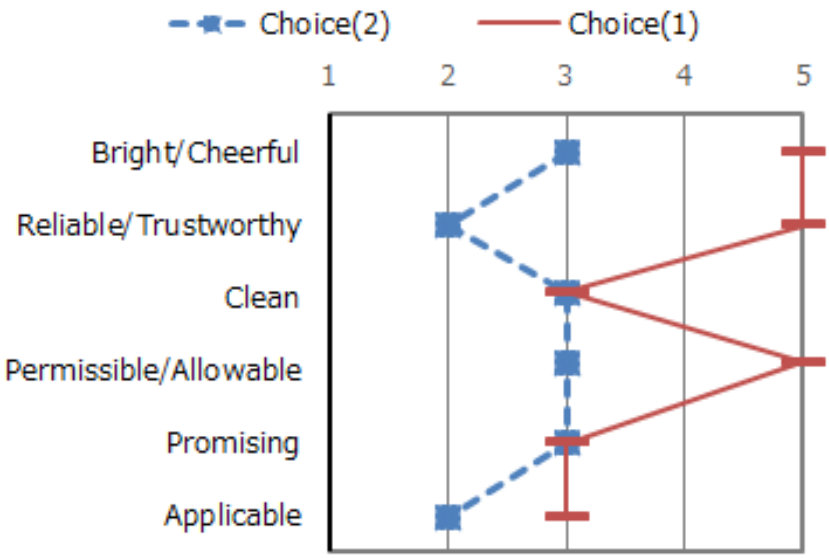


Figure 32: Semantic Differential graph.

32 shows an example graph of 5-point Semantic Differential scale and calculation. With this facility, we can choose suitable one against another through the pairwise comparison efficiently. Decision making based on choosing can be relatively easily performed. However, explanation or accountability may be another type of Semantic Differential scale and calculation.

Analytic Hierarchy Process [604][605][606] has been frequently used to facilitate making decisions even under risky or uncertain situations. AHP is one of the most powerful methodologies to realize efficient decision making [607][608][609][610]. Together with AHP, we will be able to explain what leads to the relevant result quantitatively and moreover to demonstrate quantitative mechanism of evaluation and decision [611] [612].

6.7.2 Hierarchical Expression of Problem

We have employed AHP methodology as quantitative evaluation of design results described in the previous section in order to confirm their reasonability and acceptability. As presented in Fig.32, we have six multiple criteria namely 6 factors or attributes to be considered from our colleagues in the process of collaborative poster design described below;

- attribute1: being bright or cheerful
- attribute2: being reliable or trustworthy
- attribute3: being clean

- attribute4: being permissible or allowable
- attribute5: being promising or future-perspective
- attribute6: being applicable

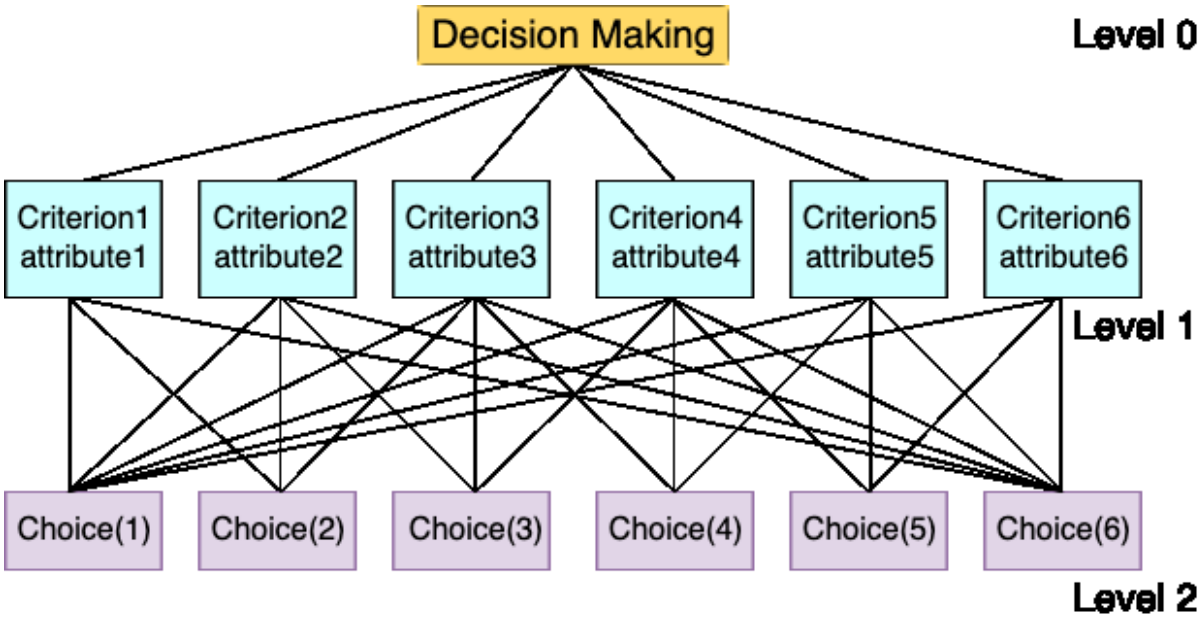


Figure 33: Problem with Multiple Criteria in Hierarchical Structure.

Figure 33 has three hierarchical structure, where Level 0 is the goal of the analysis, Level 1 is multiple criteria that consist of six factors, and the lowest level (Level 2 of Fig.33) has the alternative choices usually expressed in AHP. The lines between levels indicate relationship between criteria(factors), choices(attribute) and goal(decision making level). At Level 1, AHP provides one comparison matrix corresponding to pairwise comparisons between six multiple criteria, namely 6 factors, with respect to the goal. The comparison matrix can be expressed in **Eq(1)**.

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{pmatrix} \tag{1}$$

$$where\ a_{ii} = 1(1 \leq i \leq n), a_{ij} = \frac{1}{a_{ji}}(1 \leq i, j \leq n), where\ n = 6$$

$$\lambda_{max} \stackrel{\text{del}}{=} (1/6) \sum_{i=1}^{6} (\prod_{j=1}^{6} a_{ij})^{1/6} \tag{2}$$

$$CI = \frac{\lambda_{max} - n}{n-1}, where\ n = 6 \tag{3}$$

$$CR = CI/RI = \frac{\lambda_{max} - n}{n-1} \frac{1}{RI}, where\ n = 6, RI = 1.24 \tag{4}$$

$$PV(a_{ij}) = \frac{1}{\lambda_{max}} \begin{pmatrix} (\prod_{j=1}^{6} a_{1j})^{1/6} \\ (\prod_{j=1}^{6} a_{2j})^{1/6} \\ (\prod_{j=1}^{6} a_{3j})^{1/6} \\ (\prod_{j=1}^{6} a_{4j})^{1/6} \\ (\prod_{j=1}^{6} a_{5j})^{1/6} \\ (\prod_{j=1}^{6} a_{6j})^{1/6} \end{pmatrix} \tag{5}$$

The priority vector is obtained from normalized Eigen vector of the matrix. In order to compute the following priority vector, largest Eigen value λ_{max} must be previously calculated from a given pairwise comparison matrix. This comparison matrix has been supposed to be given in **Eq(1)**. λ_{max} of the matrix in **Eq(1)** has been calculated in **Eq(2)**.

CI and CR are consistency Index and Consistency ratio given in **Eq(3)** and **Eq(4)**, respectively. CR will be calculated with CI and RI (Random Consistency Index, 1.24 for n=6).

Typical value of RI has been provided in AHP tutorial document [607].

Thus, the priority vector $PV(a_{ij})$ for the matrix in **Eq(1)** will be computed together with largest Eigen value λ_{max} in **Eq(5)**.

6.7.3 Application of Questionnaire's Results into AHP Procedure

At Level 1 of Fig.33, we have obtained one comparison matrix corresponds to pairwise comparisons between six multiple criteria, namely 6 factors, with respect to the goal. Thus, the pairwise comparison matrix of Level 1 has size of 6 by 6 in Table 8. The diagonal is always 1.00 and the lower triangular matrix is filled using formula: "the entry of matrix at ith-row and jth-column must be equal to the reciprocal of the entry of the same matrix at jth-row and ith-column."

Table 8: Pairwise Comparison between Attribute-i and Attribute-j

	attribute 1	attribute 2	attribute 3	attribute 4	attribute 5	attribute 6
attribute1	1.00	3	5	1	2	1
attribute2	1/3	1.00	2	5	5	1
attribute3	1/5	1/2	1.00	1	2	1
attribute4	1	1/5	1	1.00	3	3
attribute5	1/2	1/5	1/2	1/3	1.00	1
attribute6	1	1	1	1/3	1	1.00

Based on survey of the questionnaire carried out previously, the comparison matrix in Table 8 has been described in the following manner, for example; In the pairwise comparison, "attribute1" has been well evaluated more than "attribute5" if and only if the entry in the 1st-row and 5th-column is 2. (automatically, the corresponding entry in the 5th-row and 1st-column is 1/2.) "attribute1" has been very well evaluated more than "attribute2" if and only if the entry in the 1st-row and 2nd-column is 3. (automatically, the corresponding entry in the 2nd-row and 1st-column is 1/3.) And "attribute1" has been highly evaluated more than "attribute3" if and only if the entry in the 1st-row and 3rd-column is 5. (automatically, the corresponding entry in the 3rd-row and 1st-column is 1/5.) Additionally, attribute1 has been evaluated as the same as attribute4 and attribute6 if and only if both the 1st-row and 4th-column entry and the 1st-row and 6th-column one are all 1's. (automatically, the corresponding entries in the 4th-row and 1st-column as well as the 6th-row and 1-st column are 1's.) In the same manner explained above, all the entries of Table 8 has been fulfilled through every Pairwise Comparison and survey of questionnaire results.

We can compute the priority vector for the corresponding matrix based on Table 8 in the following steps:

1. obtaining the corresponding matrix of Pairwise Comparison between attribute(i) and attribute(j) in **Eq(6)**,
2. calculating the largest Eigen value λ_{max} for **Eq(6)** in **Eq(7)**,
3. calculating the CI and CR for the largest Eigen value λ_{max} for **Eq(6)** in **Eq(8)** and **Eq(9)**, respectively, and
4. computing the priority vector for the corresponding matrix in **Eq(10)**.

$$matrix = \begin{pmatrix} 1.00 & 3.00 & 5.00 & 1.00 & 2.00 & 1.00 \\ 0.33 & 1.00 & 2.00 & 5.00 & 5.00 & 1.00 \\ 0.20 & 0.50 & 1.00 & 1.00 & 2.00 & 1.00 \\ 1.00 & 0.20 & 1.00 & 1.00 & 3.00 & 3.00 \\ 0.50 & 0.20 & 0.50 & 0.33 & 1.00 & 1.00 \\ 1.00 & 1.00 & 1.00 & 0.33 & 1.00 & 1.00 \end{pmatrix} \tag{6}$$

$$\lambda_{max}\ of\ matrix[6] = \lambda_{max}[6] = 6.51 \tag{7}$$

$$CI = \frac{\lambda_{max}[6] - 6}{6 - 1} = 0.1011 \tag{8}$$

$$CR = CI/RI = \frac{\lambda_{max}[6] - 6}{6 - 1}\frac{1}{1.24} = 0.081 \tag{9}$$

$$PV\ of\ matrix[6] = \frac{1}{\lambda_{max}[6]} \begin{pmatrix} 1.76 \\ 1.60 \\ 0.96 \\ 0.84 \\ 0.51 \\ 0.13 \end{pmatrix} = \begin{pmatrix} 0.27 \\ 0.24 \\ 0.12 \\ 0.17 \\ 0.08 \\ 0.13 \end{pmatrix} \tag{10}$$

The priority vector in **Eq(10)** denotes weighted vector for selecting factors/attributes described in the previous subsection 6.7.2, which expresses attribute1: 0.27, attribute2: 0.24, attribute4: 0.17, attribute6: 0.13, attribute3: 0.12 and attribute5: 0.08 in descending order. This vector plays the important role as normalized Eigenvector for six multiple criteria at Level 1 in Fig.33.

On the other hand, six normalized Eigenvectors for Choice(i) ($1 \leq i \leq 6$) at Level 2 in Fig.33 must be calculated in the same AHP way described below. In our case, Choice(i) ($1 \leq i \leq 6$) at Level 2 are our poster design examples of through collaboration based on Kansei Engineering-based approach described previously. And, Choice(1) is our **final** result of collaborative design to be published. We obtain the corresponding matrix for Choice(1) in **Eq(11)** which can be expressed through Pairwise Comparison among other Choice(j) ($2 \leq j \leq 6$) at Level 2 in Fig.33. Then we calculate the largest Eigen value λ_{max} for **Eq(11)** in **Eq(12)**, the CI and CR for the largest Eigen value λ_{max} for **Eq(11)** in **Eq(13)** and **Eq(14)**, respectively, and then compute the corresponding priority vector for the matrix **Eq(11)** in **Eq(15)**.

$$matrix = \begin{pmatrix} 1.00 & 2.00 & 3.00 & 3.00 & 5.00 & 3.00 \\ 0.50 & 1.00 & 2.00 & 2.00 & 3.00 & 1.00 \\ 0.33 & 0.50 & 1.00 & 3.00 & 2.00 & 3.00 \\ 1.00 & 0.50 & 0.33 & 1.00 & 2.00 & 1.00 \\ 0.33 & 0.33 & 0.50 & 0.50 & 1.00 & 1.00 \\ 0.33 & 1.00 & 0.33 & 1.00 & 1.00 & 1.00 \end{pmatrix} \tag{11}$$

$$\lambda_{max}\ of\ matrix[11] = \lambda_{max}[11] = 6.98 \tag{12}$$

$$CI = \frac{\lambda_{max}[11] - 6}{6 - 1} = 0.064 \tag{13}$$

$$CR = CI/RI = \frac{\lambda_{max}[11] - 6}{6 - 1}\frac{1}{1.24} = 0.052 \tag{14}$$

$$PV\ of\ matrix[11] = \begin{pmatrix} 0.36 \\ 0.19 \\ 0.17 \\ 0.10 \\ 0.07 \\ 0.10 \end{pmatrix} \tag{15}$$

By means of the same manners, other 5 priority vectors for matrices with respect to Choice(2) through Choice(6) can be calculated as follows;

$$\begin{pmatrix} 0.36 \\ 0.27 \\ 0.13 \\ 0.14 \\ 0.08 \\ 0.06 \end{pmatrix} \begin{pmatrix} 0.42 \\ 0.18 \\ 0.17 \\ 0.12 \\ 0.07 \\ 0.08 \end{pmatrix} \begin{pmatrix} 0.39 \\ 0.18 \\ 0.17 \\ 0.13 \\ 0.07 \\ 0.08 \end{pmatrix} \begin{pmatrix} 0.42 \\ 0.18 \\ 0.16 \\ 0.12 \\ 0.08 \\ 0.07 \end{pmatrix} \begin{pmatrix} 0.39 \\ 0.18 \\ 0.18 \\ 0.11 \\ 0.08 \\ 0.08 \end{pmatrix} \tag{16}$$

With the above 6 priority vectors in **Eq(15)** and **Eq(16)**, the following left-hand matrix in **Eq(17)** can be constructed in order to compute our target normalized principal Eigen vector. Such a vector will be expressed as the right side of our final equation **Eq(17)**.

$$\begin{pmatrix} 0.36 & 0.36 & 0.42 & 0.39 & 0.42 & 0.39 \\ 0.19 & 0.27 & 0.18 & 0.18 & 0.18 & 0.18 \\ 0.17 & 0.13 & 0.17 & 0.17 & 0.16 & 0.18 \\ 0.10 & 0.14 & 0.12 & 0.13 & 0.12 & 0.11 \\ 0.07 & 0.08 & 0.07 & 0.07 & 0.08 & 0.08 \\ 0.10 & 0.06 & 0.08 & 0.08 & 0.07 & 0.08 \end{pmatrix} * \begin{pmatrix} 0.27 \\ 0.24 \\ 0.12 \\ 0.17 \\ 0.08 \\ 0.13 \end{pmatrix}$$
$$= \begin{pmatrix} 0.38 \\ 0.21 \\ 0.16 \\ 0.12 \\ 0.08 \\ 0.08 \end{pmatrix} \tag{17}$$

The normalized principal Eigen vector in **Eq(17)** shows relative weights among the other Choices (alternatives) to be compared. From the corresponding Eigen vector in **Eq(17)**, it is confirmed that Choice(1) for **final** result of collaborative design has been in the most weighted score 38% rather than other design candidates. We can demonstrate confirmation of consistency in evaluating collaborative design through Kansei Engineering approach by means of AHP-based decision making methodology.

7 Discussion

The problem of this dissertation is how to realize a quantitative evaluation method for product design education.

Quantitative methods had already been adopted in product design, and the creation of a mechanism had begun, which could be flexibly applied to handle quantitatively the demands and tastes from users. For example, we could acquire the sensibilities of users, through asking and carrying out questionnaire, and then we could quantify such sensibilities based on quantification theory, as an elementary method of Kansei Engineering. It had become an environment where it was possible to analyze demand from multiple perspectives (elements and parameters) and used procedures such as pattern analysis to grasp appropriate demand. Kansei Engineering, which can quantitatively analyze sensibilities and quantitatively determine design policies, can be said to be a quantitative method for product design.

In general, in order to confirm the effectiveness of the method, it is indispensable to verify how useful the results could be obtained through individual case studies. Section 2 through section 4 were practical examples for actual verification of the above effectiveness. Although it was a classic method, we had employed test methods for verification, namely t-test and χ^2 test in section 3 and section 2 respectively.

Visualization of the design process had corresponded to the following procedures in this research. Those were,

1. to clarify what kind of options exist.
2. to formulate and to perform quantification by weighting the options, say from 1 to 5.
3. to record who have chosen the option and/or done judgment, what time designers have decided the physical quantity such as shape, color, size, etc.

It is necessary to prepare a certain prerequisite that the environment can be saved as history information.

Since there was a subjective evaluation by teachers themselves in design education, this could not be denied. Even if “subjective evaluation” was performed, we had to treat with such evaluation in visualized manners. Namely, if there were multiple evaluation axes, for example, “Promising future” or ”Clearness”, It has been important to clarify the mutual “priority” ratios among the descriptions in subjective evaluation. We must ask evaluator to compare these

descriptions, to weight them and quantify their relation as follows; the evaluation axis of "having a promising future" can be quantified as twice weighted as the evaluation axis of "being very clean". Such pairwise comparison and ratio weighting have been very important for the later procedure to quantify them suitably and smoothly.

It had been required to create a mechanism to evaluate the design objectively and quantitatively, but it was never given nor resolved that "objective evaluation" had already defined and decided as 'this' way. Even if there was an objective evaluation axis, it could be a useful mechanism by mapping such axis to relatively simple patterns such as the 5-scale points evaluation method. So we would be ready to utilize such simple patterns for several evaluation axes through measuring it quantitatively.

In creating a mechanism to evaluating design and designed results objectively and quantitatively, the following items should be particularly important:

1. we could clearly recognize what kinds of decision-making have been performed
2. we could quantitatively confirm what process of design have been determined
3. we could easily utilize scheme to make the design process reproducible.

These are extremely important not only in evaluating design but also in improving design education.

Apart from advances of design method based on Kansei engineering, the design process had been improved by collaborating with multiple people. This meaned speeding up as well as dividing the work, adding more opinions, and deepening diversity. The benefits were clear, however, such a situation would involve more numbers of parameters for complex decisions than a relatively simple design process that does everything alone. This results in enhanced design, but at the same time, complicated the design process and added ambiguity when evaluating the design and analyzing design process. As it turned out, it would be indispensable to have a mechanism that can retroactively check and confirm the following questions:

- When and who made such decisions?
- With what , it had been decided to choose by comparison ?

In other words, when designing a product by combining Kansei Engineering method and a collaborative design scheme,

1. Complex decisions were required at the design stage, and as a result, it was often difficult to verify the consistency of decisions for design.

2. The same applied to the case of evaluating a design, and when evaluating a certain design, it was necessary for multiple people to communicate with each other. As decision-making becomes complicated, then the problem of how to guarantee consistency in the decision-making process arises.

Therefore, traceability and quantification that could enable verification of complex decision-making processes performed through sensibility and collaborative work were very much important at both the design stage and the evaluation stage of design results.

To solve these problems, together with our research through my Phd course under supervision from Professor Katsunori Shimohara and moreover his Great supports and instruction,

- we have prepared a Web-based decision-making system related to design, and utilized a mechanism that can quantitatively handle qualitative factors such as sensibility and taste.

- we have acquired feedback on with what sensibilities and preferences subjective judgments were made, compare subjective judgments at the decision processes in the pairwise manner, weight the criteria of judgment/decision-making, quantify them (express them in a matrix form), and transform them into a weighted network representation of the evaluation criteria.

- we have been able to obtain a scheme for consistent judgment/decision-making by means of normalizing this matrix, namely weighted network representation of the evaluation criteria.

Specifically, at the time of design, it must be possible to support the design based on consistent decision making, and at the time of design evaluation, it must be possible to guarantee the evaluation based on consistent decision making.

Such decision-making based on consistent judgment would be suitable and available not only during design process but also at the stage of evaluating the designed results.

We have proposed a mechanism to structure, quantify, and visualize the decision-making process through application of the Analytic Hierarchy Process (AHP) into design. AHP is excellent for quantifying decision-making, verifying consistency, and proposing ways to improve more consistent decision-making, is applied to design.

By such a method

- At the case of evaluating a design made by another person, it has been possible to clarify the consistency of the evaluating side that the learner is clearly aware of the criteria for evaluation.
- At the case of designing a product design through Kansei Engineering or collaborative work (including the case of using a network), it has been able to clarify what kind of 'consistent' evaluation criteria the designer or a group of designers have employed.

In this research paper,

1. We discussed the necessity and significance of visualization and quantitative evaluation of the design process for three practical research cases for students of the design education course.
2. We developed a Web system that aggregates design parameters by Kansei engineering methods and supports the acquisition and analysis of evaluation axes in decision making.
3. We applied AHP-based calculation and transformation of qualitative factors such as sensibilities and preferences into quantitative matrix form for consistent decision-making in multiple criteria related to design.
4. We proposed a mechanism to structure, quantify, and visualize the decision-making process related to design for the sake of elimination of ambiguity of design evaluation, inconsistency of determination in design process and Learners' anxiety for design education.

8 Conclusion

Section 2 describes a practical model of Reproductive Design Education utilizing services based on Knowledge and Resource Discovery through SNS community. And it also explains the characteristics and advantages from scheme of our proposal for Reproductive Design Education in Detail, and illustrates a practical flow for proposed Reproductive Design Education utilizing several kinds of services from SNS community with comparison of conventional design process in design education. Knowledge, Resources, Tools obtained from SNS community can realize a fruitful reproductive design education. In the case of furniture reproduction, our proposed Reproductive Design Education has brought important and significant values to learners as well as their according SNS community. Such values include resource recycling, tool sharing, energy saving, cost-performance, knowledge retrieving/ mining and so on. With the above discussion, it can be summarized in this paper as follows:

① Reproductive Design Education has provided the effect and evidence of recycling, ecology and cost saving.

② Reproduction of furniture, itself, as a good example of proposed Reproductive Design Education can play a certain role of utilization of services about Knowledge and Resource Discovery from SNS community.

③ Reproduction, sharing and recycling with support from networks seems to be some case study of Resource and Knowledge Discovery through SNS community.

④ Qualitative and quantitative evaluation have been performed for limited members of learners as well as larger size of ones in classroom level.

⑤ Results from qualitative and quantitative evaluation can allow us to consider that it is confirmed for our proposed scheme to provide learners ' satisfaction for Reproductive Design Education utilizing SNS community through Knowledge and Resource Discovery.

Our future plan is to provide more suitable educational schema and practical models for schools/ institutes to employ more fruitfully and smoothly.

Section 3 describes an example approach of collaborative design through Internet community, which is implemented to provide an idea to reconstruct some living space and environment for people who had been attacked by disaster such as Earthquake and especially Huge Tsunami. We

want to provide a visual design concept of living space for slope topography, which is normally seemed not to be suitable for ordinary living but to be of advantage for avoidance of disaster near from sea shore especially. With our approach, we can conclude as follows:

① It is necessary to discuss more suitable design concept and/or idea for people who want to have temporary or permanent living environment, because they have been damaged by disaster. We decide to employ efficient and effective approach which can be faster and more flexible than usual.

② It is suitable and convenient for people to provide their idea for some domain by means of Internet community such as social network system. Utilization of "Facebook" is to obtain several comments and messages from community.

③ Kansei engineering is good enough to evaluate proposals and analyze their comments, notices and criticism from community, because of being qualitative ways and data.

As one of our future works, we will develop new information server system to provide an efficient environment for collaborative design and analyze inbound comments and criticism for specific idea and design concept by means of Kansei engineering methodology. In addition, we will demonstrate the effectiveness of our collaborative design strategy by means of some kind of simulation according to the reviewers ' constructive suggestion. We want to communicate with people who consider to live where they are really afraid of potential damage of Tsunami and discuss about our original plan/design concept of living space for slope topography through SNS and/or Internet community.

Section 4 describes the Campus-based Information sharing and decision making system for collaborative design. The system provides some functions for viewing proposal, exchanging comments and criticism, and finally performing vote casting. The system has been applied into design and building of the practical problem to create the poster of entrance promotion of the college. With the system, such a time-consuming task can be accomplished in a relatively short period. It is confirmed that the system can support all the members of committee perform their decision making reasonably and acceptably. Additionally, the paper illustrates the real collaborative design process in detail. Without this system, such collaborative design would be handled on the according environment just like SNS. But such an SNS cannot provide reasonable methodology to accomplish decision making by vote casting with weight added priority. As one one of future plans, The Information sharing and decision making system will be applied into

several domain in practical problems on collaborative design. From this work, the following experiences has been obtained, which are very important to develop and application of some kind of Information System to provide an environment of effective information sharing and strategic decision making:

① Some kind of real-time feedback mechanism is necessary to share valuable information among the closed members.

② It is good enough to provide mechanical evaluation by Kansei Engineering in order to perform strategic decision making.

③ It is very important to equip priority-based vote casting mechanism to accomplish collaborative design in a relatively short period.

It will be expected to improve the precision of decision-making through Kansei Engineering and user-interface of the system for other future targets based on this time accomplishment.

Section 5 describes Web-based questionnaire system to carry out questionnaire for learners of design education in order to evaluate product design and its level of excellence, how to manipulate Web page between "Questionnaire Editing Users" and "Answer Writing Users", and then practical design process of the official poster for the conference by means of utilizing the above questionnaire system, which are summarized as follows.

① From questionnaire, Fig.26(b) is selected as the hot favorite for the official conference poster.

② From questionnaire, Fig.28(b) is well evaluated by Japanese, it is not so well evaluated by possibly participating foreign researchers.

③ Finally, Fig.26(b) has been selected as this year's official poster design for the conference.

Section 6 describes our Campus-based Information sharing and communicating system for collaborative design. The system provides some functions for viewing proposal, exchanging comments and criticism, and finally performing vote casting through Questionnaire answering facility. We have applied our system into design and building of the practical problem to create the poster of entrance promotion of the college. Our previous determination of final design for large promoting poster can be confirmed by AHP-based decision making methodology. It

is confirmed that our system can help all the members of committee to perform their decision making reasonably and acceptably.

Additionally, by means of applying AHP decision-making approach into verification of previously determination of candidate of promoting poster, the second half of this paper confirms quantitative evaluation of design results through collaboration.

From this work, we have obtained the following experience, which is very important to develop and application of some kind of Information System to provide an environment of effective information sharing and strategic decision making;

① Some kind of real-time feedback mechanism is necessary to share valuable information among the closed members.

② It is good enough to provide mechanical evaluation by Kansei Engineering approach in order to perform collaborative design effectively.

③ With AHP decision-making methodology, determination of candidate of promoting poster can be confirmed by quantitative evaluation of design results through collaboration.

Of course, we consider that Kansei Engineeringand Collaborative Design have been frequently explained and illustrated as useful methodologies for good product design. So we have showed our proposal of utilization of Kansei Engineeringand Collaborative Design for our Product Design Education by means of practical examples. At the same time, however, we used to need not only good strategy for utilization of Collaborative Design with easy information sharing but also good methodology for Kansei Engineeringprocedure with traceability and/or easy confirmability of decision making. Web-based questionnaire system will be useful for Collaborative Design with easy information sharing, while Confirmation with AHP-based decision making methodology also will be convenient for Kansei Engineeringprocedure with traceability of decision making. And we are sure that we will be able to extend our same approach and solution about utilization Kansei Engineering-based product design and Quantitative verification of designed results through AHP methodology to more useful fields of education not only in product design but also other attractive ones.

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