

EVALUATION OF USABILITY METHODOLOGIES IN THE UNIVERSAL DESIGN PROCESS

Yasuyuki Hirai¹, Yoshitsugu Morita¹, Nermin Elokla¹

¹ Department of Human Living System Design Faculty of Design, Kyushu University, Japan

ABSTRACT

The present study aims to define and evaluate usability methodologies, showing where they could be used in the universal design (UD) process. It compares a theoretical prediction against practical examples from across the globe and theorizes on the differences between the two. According to the literature survey, we proposed a chart that could guide whether designers, researchers, etc to use adequate usability methods through the design process cycle. We contacted with some institutions and centers for universal design in the United States, Europe and Japan in order to assess our proposal and assure of its adequacy. The results of this study are the following:

1. The term of usability has two definitions based on the purpose, usability design and usability testing. The former one is concerning the users' requirements and problems. The latter definition is concerning the evaluation of the prototype and its performance.
2. The opinions and the answers of the institutions and the centers on the chart revealed that theory is a good indicator, but practical experience is somewhat different. Some of the contact institutions and centers agree on the chart, but others suggested and added more techniques. The differences in the answers of the contact institutions and centers can be due to many factors, such as, consumers, culture, context, environment, budgets, etc.
3. We need to test our proposal widely, for example by contacting industry and consultative organizations. The intention is to capture data across the spectrum of universal design experience so that it will be useful to see how to teach UD for students and what methods are most useful for industry. This study will be interest for design practitioners, educators, students and decision makers and also to innovators or anyone involved in commissioning design.

Keywords: Usability Methodologies, Universal Design Process, Product Design

1 INTRODUCTION

Not only will tomorrow's populations be older, but they will be more demanding in how they choose to live and accommodate age, disabilities and illness. They will require products and services that are flexible, that can accommodate a wide range of different capabilities, yet which reflect diverse lifestyle aspirations, and enable active and healthy ageing [1]. Based on our previous study concerning the universal design process, the authors detected that interaction between designer and user is often required and beneficial at every stage of the design process [2]. Universal Design (UD) has been introduced as a tool to avoid a divergence between designers and users [3]. It is defined as "the design of products and environments to be useable by all the people, to the greatest extent possible, without the need for adaptation or special design"[4]. Usability methodologies are concerning the different ways of interaction between designer and users. The term usability was first popularized in the early 1980's as focus from programmer-computer interaction to user-computer interaction. Usability methods are often utilized during successive phases of product development, with the intention of making product use more efficient and attractive to customers [5]. There are many studies discussed the term of usability and its definitions [6], [7], [8]. The studies that discuss usability assessment methodologies in the design process are limited. This study defines and evaluates usability methods and tries to identify when they could be used in the universal design process cycle.

2 METHODS

First, a literature survey was done to identify and clarify usability methods. Secondly, we analyzed and evaluated each method based on four issues: aim, number of users needed, advantages and disadvantages. According to the literature survey, a chart was proposed so as to determine when each method could be used in the design process. Thirdly, the proposal was assessed by three institutions and centers in the United States and Europe. The intention was to know their opinions and comments on this chart. Interviews were also carried out with universal design professionals in Japan. We received the answers from the Center for Universal Design (CUD- USA) and the Helen Hamlyn Centre (HHC-UK) and the Institute for Integrated Design (i/i/d- Germany), both of which practice universal design. Fourthly, a comparison was done between the authors' proposal (the theoretical prediction) and the centers' proposal (the practical examples) in order to identify the differences between the two.

3 RESULTS AND DISCUSSIONS

3.1 Universal design process cycle

In the previous study, the authors tried to propose the cycle of universal design process as a guideline for people who work in this area [2]. In the beginning of the project, a designer has to identify the design brief. For example, what is going to be designed? And what does the designer need to know? Then apply the following stages (Figure 1):

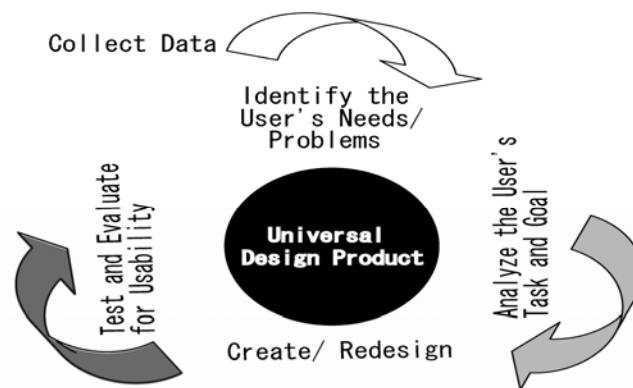


Figure 1. The Cycle of Universal Design Process

First Stage “collect data”: to design a product that fits for as many as possible of users (including different abilities and generation), we have to learn about their abilities, aspiration and background in the early stages of the design process. In addition, a designer has to consider the environmental context and the product environment and its market.

Second Stage “identify the users’ needs/problems”: a designer has to assess the user/users’ needs, and define the difficulties they have and try to extract the problems.

Third Stage “analyze users’ tasks and goals”: this stage of the design process is important because what users say they do and they actually do, are often different. People often cannot remember exactly how they use a product.

Fourth Stage “create/redesign”: It includes: idea generation, basic design and implementation design. Throughout each of them, a design is assessed and checked by user and designer in order to assure that it satisfies user’s requirements and legal standards. Idea generation is concerning a preliminary mental image of required product. The images are responding to the getting information from the users and a designer’s experience. Basic design is concerning the selected idea/s for drawing schematically (including plan, sections, elevations, and perspectives) so as to give user an idea of what the final product will be. The selected idea is usually the best one that fulfils the users’ needs. Implementation design is concerning a design that is selected for manufacturing.

Fifth Stage “test and evaluate for usability”: testing a prototype is an iterative process; it is important to conduct usability testing through the development cycle [9]. Once a prototype exists, a designer needs to test and evaluate it, so as to know if it satisfies the seven principles of UD and meets the users’ needs or not.

3.2 Definition of usability

Usability is the extent to which a product can be used by specified users to achieve goals with effectiveness, efficiency and satisfaction in a specified context of use [10]. Another study mentioned that usability refers to the efficiency, comfort, safety and satisfaction with which a wide range of people and under a variety of conditions can perform their tasks with a product. It is much more than a measure of how easily a thing can be used, and it encompasses all aspects of the product and its use [11]. In another study, the authors defined usability as that the people who use the product can do so quickly and easily to accomplish their own tasks. This definition rests on four points: 1) Usability means focusing on users; 2) people use products to be productive; 3) users are busy people trying to accomplish tasks; and 4) users decide when a product is easy to use [12]. One more study mentioned that usability starts with a philosophy- a belief in designing to meet user needs and to focus on creating an excellent user experience – but it is the specific process starts by looking at who uses a product, understanding their goals and needs, and selecting the right techniques to answer the question, “How well does this product meet the usability requirements of the users?”[13]. Based on the previous definitions, it is essential to involve user/users in the every stage of the design process. This study classifies the meaning of usability according to the purpose in two categories (Figure. 2): a. Usability design: since first, second, third and fourth stages of the design process require collecting information and data about the user’s context, requirements, problems, as well as the product environment, we called these stages “input”. Usability design has different ways to gather enough information about the users for designing a product that meet their needs. Basically usability design has three activities: A) Requirements collecting: understanding and specifying the context of use. B) Requirements specification: specifying the users’ needs. C) Create/ redesign: producing designs and prototypes. b. Usability testing: it aims to examine and evaluate the prototype “output”. Usability testing has some techniques for examining and evaluating prototype usability throughout its life cycle. The life cycle of a prototype means for example, packing, instructions, set up, use, maintenance, and disposal. Usability testing is important to know how well a prototype satisfies the users’ needs.

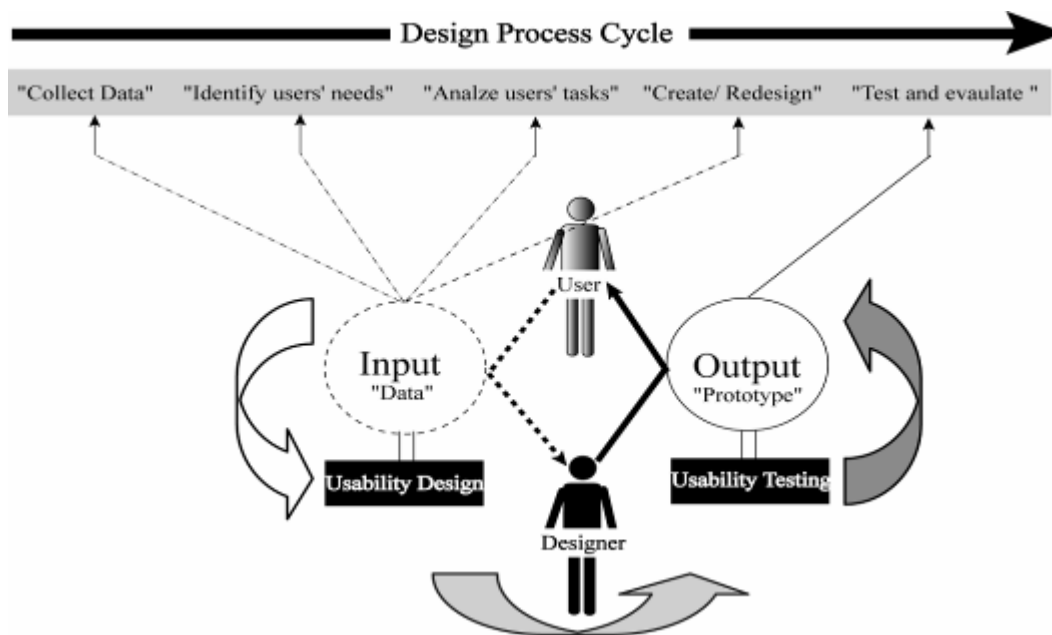


Figure 2. Definitions of Usability Term

3.3 Usability assessment methodologies

According to the literature survey, we found that there are many techniques used for interacting with the users during the design process. This study defines and evaluates 8 usability methods. The selected methods are commonly used through the design process [14], [15]. The results of the survey revealed the following:

A. Contextual inquiry:

It is a technique for examining and understanding users and their workplace, tasks, issues and preferences. It can be used to produce user needs' analysis and task analysis. Contextual inquiry is more a discovery process than an evaluative process; more like learning than testing [16]. It is based on three core principles: that understanding the "context" in which a product is used is essential for elegant design, that the user is a "partner" in the design process, and that the usability design, including assessment methods like contextual inquiry and the usability testing, must have a "focus". This technique follows many of the same process steps as field observations or interviews. The difference is that interviewing during a contextual inquiry study usually does not include set, broadly worded questions. Instead, the partnership between the interviewer and interviewee is used to create a dialogue, one where the interviewer cannot only determine the user's opinion but also his or her motivation and context. Two people should be involved in any site visits, if possible. It is best used in the early stage of the design process, since a lot of the information you'll get is subjective, ex., how people feel about their jobs, how work, etc [17].

B. User interview:

This elicits information about user's experiences and preferences. An interview is formal, structured technique where one interviewer talks with usually one participant at a time for one hour [18]. It can be used at any stage of development, depending on the questions that are asked. More likely, though, it is employed early in the design process in order to gain a more detailed understanding of a domain/area of activity or specific requirements [17], [19]. The advantages of this method are: 1. a participant's unique points of view can be explored in detail. 2. Any misunderstanding between the interviewer and user can be quickly identified and addressed. The disadvantage of the interview is that users just provide their opinions and time consuming [20], [21].

C. Focus group:

A focus group is a somewhat informal technique that involves encouraging an invited group of intended/actual users of product to share their thoughts, feelings, attitudes and ideas on a certain subject [22], [23]. It can be used at any stage of development, depending on the questions that are asked. More likely, though, it is held at very early stages of development, when the product requirements are still not firm [7]. Basically, it is used as an input to design [24]. In the focus group, the designer brings together 6 to 12 users to discuss issues and concerns about the features of a user interface. The group typically lasts about two hours [21], [18], [19]. The benefit of this method is that if a person raises an idea, another person in the group could then develop and expand that idea. Also it allows for spontaneous reactions from participants and an opportunity to observe group dynamics. The disadvantages of this method are that takes time to recruit participants and schedule sessions [20].

D. Card sorting:

It aims to learn how users think about a product and how they would design it. Card sorting is a method for suggesting intuitive structures/ categories. A participant is presented with an unsorted pack of index cards. Each card has a statement written on it that relates to the design of the product. The participant is asked to sort these cards into groups and then to name these groups. The results of multiple individuals' sorts are then combined and analyzed statistically (Figure. 3).



Figure 3. Card Storing [17]

This technique is best used in the early stages of development [17]. The reason is to assure that a design reflects the way users logically organize items, but can be done at any stage. The number of users needed is at least 10 but best with a minimum of 20 persons. The advantage of this method is showing a designer how users would organize and name the information on a design. The disadvantage is that it is difficult to analyze the results with small number of users [20].

The following steps can be used for preparing this method [25]: a) ensure that each term is as clear and unambiguous as possible. b) Ensure that you have included all the items you need to categorize. c) Randomize cards prior to each participant session. d) Script a set of instructions so that all participants have the same understanding of the process. e) Leave participants alone while they are sorting the cards to avoid placing them under unnecessary time pressure.

E. Field study/ User observation/ Ethnographic study:

It is carried out by observing the users as they do normal tasks [20]. This is done in their natural environment, e.g. office, or home. This method aims to view what users actually do in context and how interact with a product. Observer can take notes. Also audio and video recordings may even be possible to use. When conducting an observation, the observer should stay quiet most of time. The goal is to become virtually invisible to the users so that they will perform their tasks in the same way they normally do. It is often used in the early stages of the development [21]. The number of users needed is from 3 to 5 persons. The main benefit of this method is that provides a designer with an opportunity to see actual users as they use the product in their own environment The disadvantage is that field study is not structured, so may be hard to compare data from different users [20].

F. Questionnaire:

A set of questions designed to collect responses and opinions from the users [17]. Users are asked to fill out the questionnaire and return it to the designer. There are three basic types of questions: First, factual- type questionnaire which means that such questions ask about public, observable information that it would be tedious or inconvenient to get any other way. Second type is opinion-type questions. These ask the respondents what they think about something or someone. There's no right or wrong answer, all we have to do is to give the strength of our feeling. Third type is attitude questions. These focus the respondent's attention to inside themselves, to their internal response to events and situations in their lives. The questionnaire can be used at any stage of development, depending on the questions that are asked in the questionnaire. The number of users needed varies but it is good to have large groups. The advantage of this technique is that a designer can get feedback from a large group easily [26]. This technique's disadvantage is writing an effective questionnaire takes skill [20].

G. Performance testing:

Performance testing sessions examine a prototype by collecting data from people as they use it. A participant is invited to attend a session in which they perform a series of tasks while a designer takes note of any difficulties they encounter. Participants are asked to "think out loud" about their thoughts, reactions and feelings [19], [24]. The designer collects data on how they are doing, for example, how long they take to perform the task, or how many errors they make [17]. The purpose of this test is to identify usability problems so that they can be solved prior to finalization of the product. The number of users needed is between 5 to 10. It could be conducted at any stage of the design process to ensure that the design is staying on track [18]. Main advantage of this technique is providing an opportunity to see actual users as they use a design. The disadvantage is that it is time consuming to organize [20].

H. Heuristic evaluation/ Expert evaluation:

Evaluators analyze and judge the design based on a set of usability principles. The intention is to find the usability problems [17]. In general, heuristic evaluation is difficult for a single individual to do because one person will never be able to find all usability problems. Basically, different people find different usability problems. It is possible to improve the effectiveness of the method significantly by involving multiple evaluators. 3 to 5 evaluators are required to carry out this technique [23]. Each evaluator judges the design separately, then they are allowed to communicate and have their findings aggregated. This procedure is important in order to ensure independent and unbiased evaluations from each evaluator [20]. Heuristic evaluation is the most popular of the usability inspection methods [23].

According to the literature survey, this study tried to present how these usability techniques can be applied in the UD process. We focused on two issues; the research type and requiring users (Figure 4). The research type- whether qualitative or quantitative is identified for each usability technique. Qualitative design research focuses on subjective data that is not easily coded into numbers. The emphasis is on words and feelings rather than numbers. Qualitative research tends to work with fewer subjects or respondents (cases) but analyses each case to a deeper level. On the other hand, quantitative research is the systematic scientific investigation of quantitative properties and phenomena and their relationships. The objective of quantitative research is to develop and employ mathematical models, theories and hypotheses pertaining to natural phenomena [27], [28].

Usability Methods Application		Contextual Inquiry	User Interview	Focus Group	Card Sorting	Field Study	Questionnaire	Performance Testing	Heuristic Evaluation
Type	Qualitative	●	●	●	●	●			
	Quantitative						●	●	●
Requirement	With User	●	●	●	●	●	●	●	
	Without-user								●

Figure 4. Usability Methods in the UD Process

Based on the definition and the aim of each technique, we tried to identify when each usability method could be used through the cycle of the design process (Figure 5). Since the first stage of the proposed design process requires gathering information about the user's context and the product environment, we recommend a designer/developer to use contextual inquiry, user interview and questionnaire. As for the second stage of the design process, contextual inquiry, user interview, focus group, card sorting and questionnaire could be used for identifying users' needs and problems. Concerning the third stage of the design process, we suggest contextual inquiry and field study techniques to be used. The fourth stage of the design process, a designer/developer could use both of user interview, focus group, and questionnaire. Performance testing and heuristic evaluation could be used for testing and evaluating a prototype.

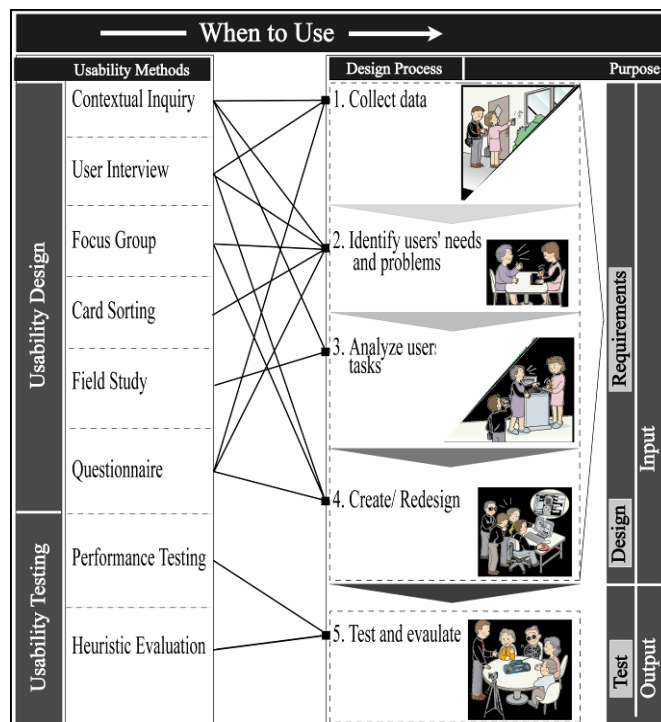


Figure 5. Authors' Proposal

The authors tried to guide designers and researchers how to carry out the design process stages. According to the literature survey, we suggested the methods which could be used in each stage of the universal design process. Since the proposal is built on theoretical survey, therefore it is assessed by Japanese Professionals in this area and the Center for Universal Design (North Carolina State University, CUD- USA) and the Helen Hamlyn Centre (HHC-UK) And the Institute for Integrated Design (i/i/d- Germany).

Japanese professional accepts our proposal. And he thinks this chart can be seen as a guide rather than strict rules. There are some projects where we start breaking these rules. The Center for Universal Design (CUD) agrees with our chart. But there are other schemes might be adopted depending on circumstances.

The following examples of the HHC and the i/i/d are built on their practical experience (Figure 6 and 7). The example that was suggested by the HHC recommends a designer to use contextual inquiry in the first, second and third stages of the design process. User interview is adequate to be used in the first, second, third and fourth stages of the design process. Focus group is effective to be used in the second, third, fourth and fifth stages of the design process. Field study is effective to be used in the second and third stages of the design process. Questionnaire is adequate to be used in the first and second stages of the design process. Performance testing is effective to be used in the fourth and fifth stages. And Heuristic evaluation is often used in the fifth stage of the design process.

In the HHC there are other usability methods, such as, user diaries which can be used in the first, second and third stages of the design process. This technique is carried out by asking user to record what he/she feels, thinks and finds everyday, then give his/her notes to designer.

On the other hand the example that was made by the i/i/d is as follows: contextual inquiry can be used in the first, second and third stages of the design process. User interview is adequate to be used in the first, second and fifth stages of the design process. Focus group is recommended to be used in the second, fourth and fifth stages. Card sorting can be used in the second stage of the design process. Field study can be used in the third stage. Questionnaire is adequate to be used in the second and fifth stages of the design process. Concerning performance testing and heuristic evaluation, the i/i/d recommends a designer to use them in the fifth stage of the design process. On the other hand, the i/i/d suggests other usability methods such as “user scenario” and “expert interview”. The first method is recommended to be used in the second and third stages of the design process.

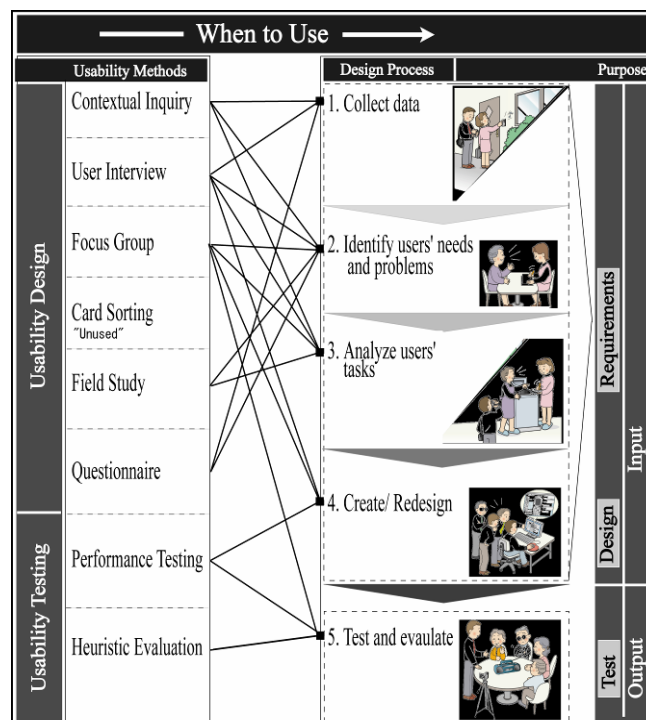


Figure 6. Example of the Helen Hamlyn Centre, by Mr.Rama Gheerawo, Research Fellow (UK)

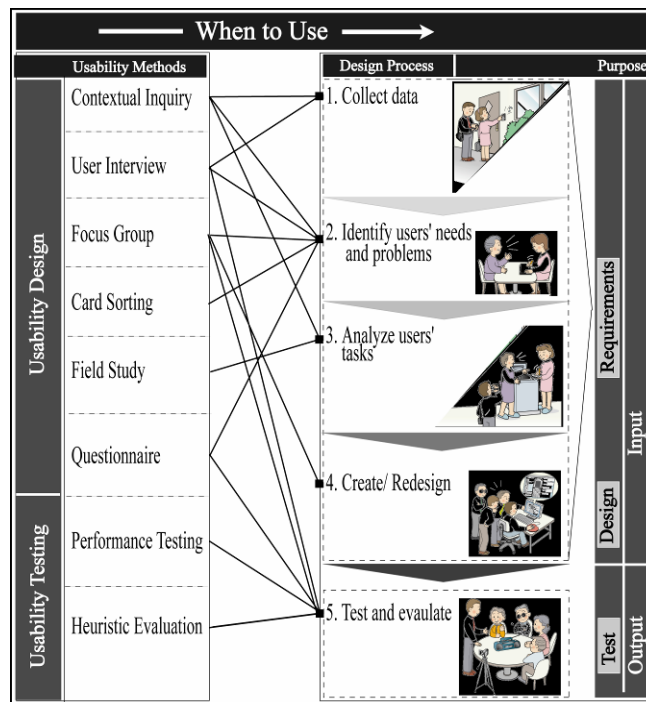


Figure 7. Example of the Institute for Integrated Design, by Ms. Melanie J. Koehler, Creative Management (Germany)

User scenario is used for knowing where the problem is. Designer identifies the user's problem and tries to analyze why/how it was done. It is the creative imagination of a future scenario from viewpoint of user. As for the second method, it is effective to be used in the first, second and fifth stages of the process. Expert interview is used for solving users' problems by making interviews with the experts in the field of these problems.

The differences in the answers of the contact institutions and centres are related to some factors such as consumers, culture, context, environment, budgets, time, etc.

We tried to combine our proposal with the examples that are suggested by the HHC and the i/i/d, so that it will be clear for researchers and designers to identify when each method can be used in the design process (Figure 8). In the combined suggestion, contextual inquiry can be used in the first, second, and third stages of the design process. User interview can be used in first, second, fourth stages. Also it might be used in third and fifth stages. Focus group can be used in the second, fourth and fifth stages. Also it might be used in the third stage of the design process. Field study can be used in the third stage. Also it might be used in the second stage. Questionnaire can be used in the first and second stages. Also it might be used in fourth and fifth stages. Performance testing can be used in the fifth stage. Also it might be used in the fourth stage of the design process. Heuristic evaluation can be used in the fifth stage of the universal design process.

The answers and recommendations of the CUD, the HHC, the i/i/d and Japanese professional revealed that theoretical proposal could be worked and used for developing UD product but practical experience is somewhat different. Therefore our proposal will be assessed more widely in order to identify the different and effective usability methods that can be used for developing UD product. In the next stage of this study, our proposal will be assessed by different manufacturers and consultative organizations which practice and use the concept of universal design (UD), so that students and educators can know more about UD, and what methods are most useful for industry.

4 CONCLUSIONS

This paper sought to evaluate usability methods and identify when can be used in the universal design process. Based on the literature survey, a proposal was made so as to clarify how to carry out each

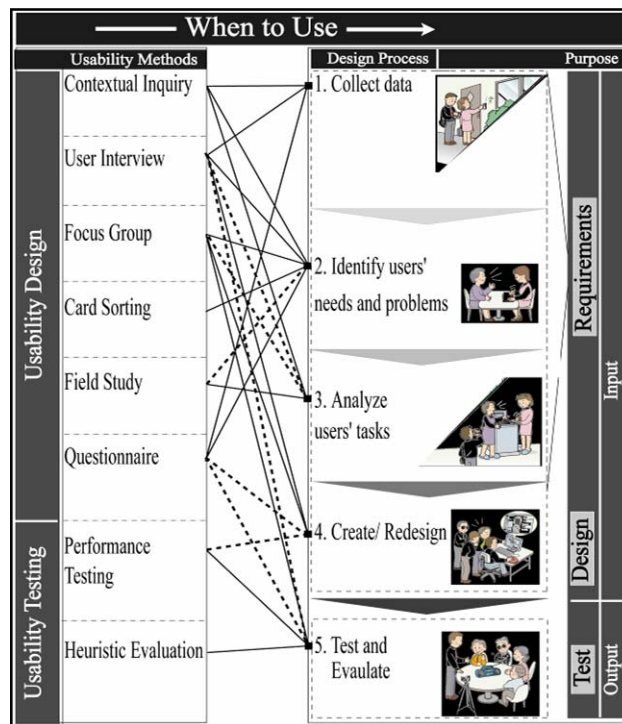


Figure 8. Combined Suggestion
 Can be used (suggested by the HHC, the i/i/d and the Authors)

 Might be used (suggested by the HHC or by the i/i/d)

stage of the design process and which usability methods could be used. The proposal is assessed by Japanese professional, the Center for Universal Design, the Helen Hamlyn Centre and the Institute for Integrated Design in order to ensure of its effectiveness and performance. This study concluded the following: first, theoretical study could be good indicator for developing UD product but practical experience is somewhat different. The examples that were made by the contact centers revealed that practical experience is essential to identify which usability methods are most useful to be used in the universal design process. Secondly, our proposal will be judged more widely in order to obtain fundamental information about UD and its design process so that it will be valuable to see how to teach this concept to students and what usability methods are helpful for industry. In the next stage of this study, our proposal will be evaluated by universal design manufacturers such as TOYOTA and TOTO and consultative organizations such as Steelcase and IDEO.

REFERENCES

- [1] Foresight Ageing Population Panel, Design for Living Taskforce, *DTI*, 2000
- [2] Elokla, N., Morita, Y. and Hirai Y., Understanding of the Concept of the Universal Design among Overseas and Japanese Institutions and Manufacturers, *Universal Design Visitability: From Accessibility to Zoning Conference, the Ohio State University, Columbus, USA, July 2006*
- [3] Ingrid, R. and Trnod, A., Inclusive, Mainstream Products, *International Conference on Inclusive Design, Royal College of Art, UK, April 2005*
- [4] The Center for Universal Design, "The Principles of Universal Design", Ver.2.0. Raleigh, North Carolina State University, USA, 1997
- [5] Burgstahler, S., Jirikowic, T., Kolko, B. and Eliot, M., Software Accessibility, Usability Testing and Individuals with Disabilities. *ITD Journal*, 2004
- [6] Oscar, P., Usability Is Not Enough, *Department Of Product Design, Norwegian University of Science and Technology*, 2002
- [7] Turkka, K., Expected Usability and Product Preference, *Department of Industrial Design, University of Art and Design UIAH Helsinki*, Finland, 1997, 197-200
- [8] Donald, A., Norman, Beauty, Goodness, and Usability. *Nielsen Norman Group, Northwestern University*.

Special Section of Human-Computer Interaction, Volume 19, 2004, 4

- [9] Raissa, K., Ten Guidelines for User-Centered Web Design. *Usability Interface*, 1998, 5 (1)
- [10] ISO/IEC, 9241-11 Ergonomic Requirements for Office Work with Visual Display Terminals (VDT)s- Part 11 Guidance on Usability, 1998
- [11] Linux Information Project (LINFO), 2006, <http://www.bellevuelinux.org/usability.html>
- [12] Janice, R. and Joseph, D., A Practical Guide to Usability Testing. *Intellect Books*, US, 1999, pp.4
- [13] Whitney, Q., Balancing the 5Es: Usability. *Cutter IT Journal*, Vol. 17, February 2004, pp.4
- [14] Stephen, B., Practical Methods for addressing the Needs of home- Healthcare Product Users. *International Conference on Inclusive Design, Royal College of Art*, UK, April 2005
- [15] Misugi, K., Kanamori, H., Koyama, N., Atsumi, B., Toyota's program for Universal Design in Vehicle Development. *International Conference on Inclusive Design, Royal College of Art*, UK, April 2005
- [16] Gaffney, G., Usability Techniques Series, Information & Design, 1999, <http://www.infodesign.com.au>
- [17] Hom, J., Usability Methods Toolbox, 2003, <http://www.Jameshom.com>
- [18] Centre for HCI Design, Usability Studies- JISC Services and Information Environment. *City University, London, Version 2.0*, 2004, pp.35
- [19] Laurel, B., Design Research, Methods and Perspectives, 2003, pp. 75, 24, 74 (Cambridge, Massachusetts, England)
- [20] Washington State University, Designing for the User: How to Test for Usability, 2002
- [21] Jakob, N., Usability assessment methods beyond testing, usability engineering. *Morgan Kaufmann*, 1994, pp. 223, 214, 207
- [22] European Commission. Information Society Technologies, tools and methods: focus group, Belgium, 2005
- [23] Jakob, N., Usable Information Technology, 1997, <http://www.useit.com>
- [24] Fidgeon, T., User-Centered Design (UCD) - 6 methods, *The Usability & Accessibility Specialists*, 2005
- [25] Gaffney, G., Usability Techniques Series, Information & Design, 2000, www.infodesign.com.au
- [26] Kirakowski, J., Questionnaires in Usability Engineering, Human Factors Research Group, Ireland, 2000
- [27] Brenda, L., Design Research- Method and perspective, pp. 23, 63, 2003 (Cambridge, Massachusetts, UK)
- [28] Patrick, W. J., An Introduction to Usability, pp 87, 88, 2002 (Taylor & Francis, UK)

ACKNOWLEDGEMENTS

The authors would like to thank the Center for Universal Design and the Helen Hamlyn Centre and the Institute for Integrated Design as well as Japanese professionals for Cooperation. This study was supported in part by Grant-in-Aid for COE Program and USI, Kyushu University, Japan.

Contact: Nermin Elokla
Faculty of Design, Kyushu University
Department of Human Living System Design
9-1 Shiobaru 4-chome, Minami-ku, Fukuoka, 815-8540
Japan
Tel: 81-92-553-4672
Fax: 81-92-553-4526
Email: nelokla@hotmail.com