

## Development and Evaluation of Educational Materials on Human-Centered Design

Jun Iio

Faculty of Global Informatics,  
Chuo University,  
Shinjuku-ku, Tokyo 162-8478, Japan  
e-mail: iiojun@tamacc.chuo-u.ac.jp

Ayano Ohsaki

Faculty of Data Science,  
Musashino University,  
Nishitokyo-shi, Tokyo 202-8585, Japan  
e-mail: a-ohsaki@musashino-u.ac.jp

Rika Waida

CX Studio,  
JVC KENWOOD Design corporation,  
Setagaya-ku Tokyo 158-0097, Japan  
e-mail: waida-rika@jvckenwood.com

Akira Kambayashi

Japan R&D Center,  
HP Japan Inc.,  
Tsurumi-ku, Yokohama, 230-0051, Japan  
e-mail: kambayashi.akira@hp.com

**Abstract** — Human-Centered Design (HCD) is the design principle that focuses on the users of services, systems, or products. The idea of HCD was proposed more than two decades ago, and it has been widely adopted in the information technology and design industries. However, entry-level educational materials are needed to increase the concepts among consumers and students who study engineering and industrial design. The Human-Centered Design Organization is a specific non-profit organization that promotes the idea of HCD in the Japanese industry. It has a working group whose members have been tasked with developing the required entry-level educational materials on HCD and promoting them to the industry. This paper describes some of its activities. As per the HCD cycle itself, we distinguish between the development and the promotion of the materials. In addition, we explain the relevance of the educational materials the working group delivered by illustrating the results of the questionnaire administered after the introductory seminar to those who are not familiar with HCD. Their efforts have been of great value to the people who must teach HCD concepts to newcomers.

**Keywords** - human-centered design; educational materials; HCD cycle.

### I. INTRODUCTION

Human-Centered Design (HCD) is the concept of a design process where the developers design their services, systems, or products focusing on their users. That is, HCD is considered a user-oriented design process. HCD was proposed more than two decades ago, and it was standardized by the International Organization for Standard (ISO) as ISO 13407 in 1999. Also, it was integrated into ISO 9241 in 2010 (ISO 9241-210:2010), adding the concept of User Experience (UX). Subsequently, it was updated to ISO 9241-210:2019 in 2019 [2].

In conventional industrial design, designers tend to focus on their design convenience. However, it often leads to the

users' inconvenience. HCD solves such problems by prioritizing users' requirements rather than developers' options.

In Japan, a non-profit organization, the Human-Centered Design Organization (HCD-Net), was established in 2004 [3]. HCD-Net aims to assemble knowledge on HCD and to promote methods and skills regarding HCD. With their long-term efforts, the concept of HCD has been widely adopted among experienced engineers, especially in the information technology and design industries. However, it is still not popular among consumers. Surprisingly, even students learning engineering and industrial design are not familiar with the HCD concepts [4]. Therefore, entry-level educational materials are needed for training newcomers to perform HCD processes appropriately.

Although there are many training services, educational materials, books, and seminars for the higher-level training on HCD activities, unfortunately, we have few items that can be used as the educational material for introducing basic knowledge of HCD.

Several Working Groups (WGs) were established in HCD-Net to fill the gap between entry-level and high-level education due to the lack of educational materials. The members of these WGs have been actively working to achieve their goals. "The fostering teachers WG" was established in June 2016, and it meets monthly for face-to-face discussions. In addition to the meetings, several events have been held by the WG, and the work has been actively progressing [1], [5]-[8].

The rest of the paper is structured as follows. In Section II, we present the basic idea of the HCD process. In Section III, literature reviews are described. In Section IV, the WG's strategies are illustrated. Then, in Section V, we discuss how the HCD process worked in the WG's activities and the value of the educational materials delivered as their work. In Section VI, the evaluation of the educational materials that the WG provided is explained. Finally, conclusions, future work, and the acknowledgment close the article.

## II. THE HCD PROCESS

Before explaining the WG's activity further, we describe the basic idea of the HCD process better to understand the character of the WG's work.

The HCD standard is a process standard, i.e., the standard defines several processes to realize an efficient design from a user's viewpoint. The general phases of the HCD process can be explained with the following steps: (quoted from [9]).

- *Specify context of use:* Identify who the primary users of the product, why they will use the product, what are their requirements and under what environment they will use it.
- *Specify Requirements:* Once the context is specified, it is the time to identify the granular requirements of the product. This is an important process which can further facilitate the designers to create storyboards and set important goals to make the product successful.
- *Create Design solutions and development:* Based on product goals and requirements, start an iterative process of product design and development.
- *Evaluate Product:* Product designers do usability testing to get users' feedback of the product. Product evaluation is a crucial step in product development which gives critical feedback of the product. The important point is that this cyclical process must be repeated several times to satisfy the service level of the users' requirements.

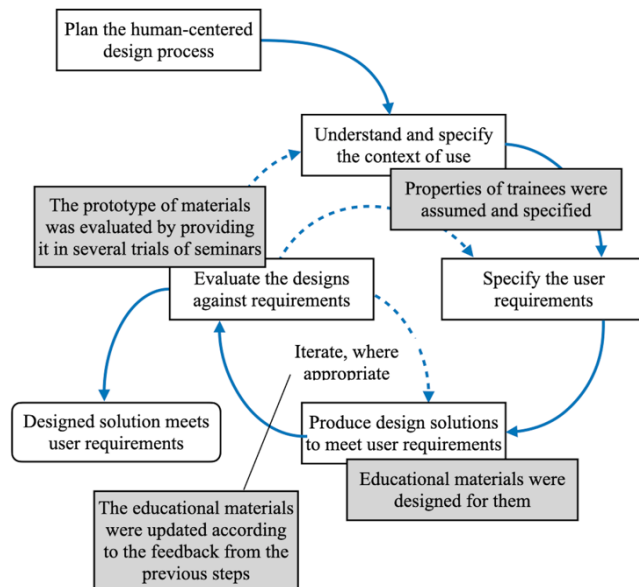


Figure 1. The WG's activities, along with the concept of HCD defined in the ISO 9241-210.

WG members oversaw creating the entry-level materials and training the trainers who can teach the basic concepts of HCD using their materials.

The fact that their activities themselves were based on the concept of HCD should be noted; that is, the designing process of their products was as follows: 1. Properties of train-

ees were assumed and specified. 2. Educational materials were designed for them. 3. The prototype of materials was evaluated by providing it in several trials of seminars. 4. After that, the educational materials were updated according to the feedback from the previous steps. Figure 1 illustrates the processes defined by ISO 9241-210 and the cases adopted to WG's activities in each step, respectively.

## III. LITERATURE REVIEW

As the concept of HCD is more widely recognized, HCD education is gathering more and more interest from engineers in various fields. Instructors in this field are paying particular attention to how to teach UX concepts. Some case studies in universities and professional training colleges have been reported. However, it remains unclear how to help newcomers understand HCD in the entire business field.

Ito *et al.* [10] reported their implementation of the e-learning course on the basics of HCD. They were working for a computer-electronics manufacturer, and their e-learning course was intended to prevent miscommunication regarding user interfaces among the employees. It was an excellent example of HCD education conducted in the enterprise.

Gonzalez *et al.* [11] surveyed 140 students of the Human Factors and Ergonomics Society (HFES) and analyzed 40 UX job postings. The results show a discrepancy between the skills the UX industry expects students to have and the skills HFES promotes for a career in UX. They recommended a focus on increasing HFES's relevance to students interested in future UX careers. Vorvoreanu *et al.* [12] also reported on the UX education for undergraduate students at university.

The concept of "design thinking" is a similar idea to UX design. Wrigley *et al.* [13] focused on surveying the design thinking education provided as Massive Open Online Courses (MOOCs). MOOCs are open to the public, and most can be participated in for free via the Internet. Therefore, anyone who wants to learn about design thinking can acquire knowledge by accessing the courses presented on their websites.

Dirin and Nieminen [14] studied the relevance of User-Centered Design (UCD) education to a mobile application development course implemented in a university. They analyzed the feedback from students and concluded that UCD education had a significant role in the development and improvement of students' capabilities on consulting and user study research.

We can find many other cases where HCD or UCD processes were introduced to education programs in various fields; Adam *et al.* [15], Organ *et al.* [16], and Carter *et al.* [17] reported cases in health and medical education, Harvey *et al.* [18] reported an issue in fashion education, Wilson *et al.* [19] discussed the possibility of applying the UCD approach to the training environment for aircraft maintenance personnel. Bowie and Cassim [20] argued for the HCD methodology in contemporary communication design education. These papers reveal the presence of a potential need for HCD education in various domains.

Additionally, there are some studies on designing or evaluating a curriculum by incorporating HCD processes

similar to our approach in creating their educational materials. Altay [21] pointed out a similarity between the learner-centered approach in education and the user-centered approach in design disciplines. Altay illustrates this by adopting a user-centered approach within the human factors course as learner-centered instructional methods. Reich-Stiebert *et al.* [22] explored robot design education employing the HCD approach. They investigated students' preferences regarding the design of educational robots and evaluated the course according to the results. Chen *et al.* [23] reported on evaluating the curriculum using a method of creating student personas in the field of resource engineering education.

#### IV. THE WG'S STRATEGIES

The WG's activities' starting point was the textbook published as the first of the HCD book series. Based on the contents of the book, the WG considered two strategies; one was to develop presentation slides and guidebooks as the educational materials, and another was to foster trainers who could provide seminars to newcomers who were not familiar with HCD.

Under these strategies, the WG created two prototypes of the educational materials for engineers and salespeople. Furthermore, some simulated seminars were conducted to acquire feedback and opinions to brush up on the materials.

##### A. Educational Materials for Engineers

The first target was newbie engineers who were not familiar with the concept of HCD. The WG published a beta-version of the presentation slides in June 2017, after several discussions by the WG members. After collecting some feedback, the materials were updated, and version 1.0 of the document was published in May 2018.

The presentation materials have 42 slides, which are intended for conducting a seminar of approximately one-and-a-half hours. An overview of the contents is as follows:

- Case studies
- The concept of human-centered design
- Usability
- Introducing the HCD cycle
- Appendix (good practices)

Figure 2 shows some examples of the document. The upper left of the figure is the cover page, the upper right shows a sample from the case studies, the lower-left illustrates the HCD cycle, and the lower right is the cover of the appendix.

As seen from the small icon at the corner of the cover page (see the upper left of Figure 2, the materials are published under the license of Creative Commons (CC BY-NC-SA 3.0). Therefore, everyone can share, redistribute, modify, and create deliverables based on this product, if they follow the conditions defined by the CC license. This licensing strategy is beneficial for future trainers, whom the WG also wants to encourage because those educators can modify educational materials as they like.



Figure 2. Examples of the presentation slide for training engineers.

##### B. Educational Materials for Salespeople

After creating the entry-level educational materials on HCD for engineers, the WG started a discussion on another version of the educational materials. The members of the WG considered that the people in the front office who had contact with their customers had to know the HCD concepts. Especially in the case of business to business (B2B), such businesses require customers' understanding and cooperation. Hence, the WG decided on salespeople as the next target for education on the idea of HCD.

At the beginning of the preparation work, the WG invited some salespeople and producers who were using HCD processes and worked directly with their customers in their daily business activities. The WG members had several interviews to learn about their thought processes, how they worked with their customers, etc. Also, they invited salespeople who did not know the HCD to attend an entry-level HCD lecture so that the discussions could be fruitful for both sides.

Although the base materials were those for engineers, minor modifications were made to the original ones. There were two significant changes; one is that the thoughts of the customer-orientation investigation were introduced instead of the case studies. The other was that the discussion on the positioning of the HCD was added before the conclusions. The latter part also mentions User Experiences (UX) because UX is also a key topic for discussing HCD-related issues with customers.

The overview of the contents for salespeople is as follows:

- Considering the view of the customer-oriented
- The concept of human-centered design
- Usability
- Introducing the HCD cycle
- Positioning of the HCD
- Appendix (good practices)

The education materials of the HCD for salespeople were released in May 2019 (version 1.0).

C. Guidebooks

In addition to providing the presentation slides, the WG also supplies a guidebook on how to conduct efficient training on HCD. Generally, it is not easy to run seminars along with the presentation materials when they were created by other individuals. Therefore, guidebooks for training courses for trainers using two versions (for engineers and salespeople) of educational materials are also provided.

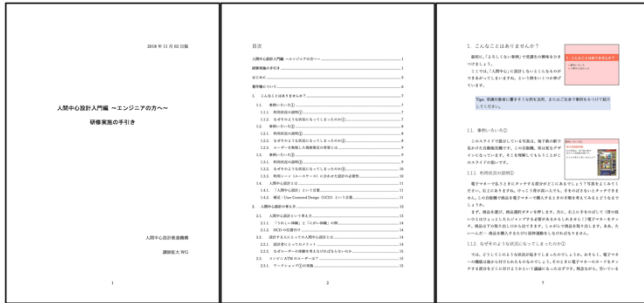


Figure 3. Examples of the presentation slide for training engineers.

Figure 3 shows some examples of the guidebook for the educational materials for training engineers. The left figure is the cover page, the middle shows the table of contents, and the right shows one of the instructional pages.

As shown on the right in Figure 3, the instructions are described for all presentation slides. The guidebook helps novice trainers by giving some additional information on how to teach the topics, etc.

All the educational materials (presentation slides) and complementary guidebooks are uploaded to the server hosted by HCD-Net. These can be downloaded from [24] (for engineers) and [25] (for salespeople).

D. Simulated Seminars (Trial Events)

To evaluate the prototype of the educational materials and lectures, the WG held five simulated seminars. Table 1 shows a list of trial events officially announced by HCD-Net.

TABLE I. THE LIST OF TRIAL SEMINARS

ID	Target	Version	Date	Participants
1	Engineer	Alpha	Mar 4, 2017	18 pros and beginners
2	Engineer	Beta	Aug 29, 2017	10 pros and beginners
3	Engineer	Ver. 1.0	May 25, 2018	21 pros and beginners
4	Salesperson	Beta	Jan 19, 2019	18 pros and beginners
5	Engineers & Salesperson	Mofidied	Dec 19, 2019	26 (mainly) beginners

The target of the first three seminars (ID 1, 2, 3) was the version for engineers. Lectures based on alpha, beta, and version 1.0 were examined in each trial, respectively. The next one (ID 4) was for salespeople. At that time, the beta version of lectures for salespeople was confirmed. We asked for HCD professionals to participate in those trials (from ID 1 to ID 4). Therefore, we could hear various opinions from

not only beginners but also from professionals. Furthermore, the trial seminars were helpful for those professionals because most of them oversaw human resource development. They were motivated to take the contents of the entry-level workshops back to their companies.

V. DISCUSSIONS

As described in the previous section, the WG created the educational materials and guidebooks according to the HCD processes. This section discusses the compliance with such methods and the values of the WG’s products.

A. How the HCD Process Worked in the WG’s Activity

Looking back, in this section, we consider how the four steps in the HCD cycle were applied to the WG’s activities. We recall that the HCD cycle has four phases: specifying the context of use, specifying requirements, creating design solutions and development, and evaluating products.

1) *Specify Context of Use:* As we described in the introduction of this paper, our study aimed to create entry-level educational materials and encourage the instructors who present the training in their organizations. Considering the situations and experiences of each WG member [5][6], the WG decided on engineers as the first target group of trainees and then salespeople as the second target group of trainees.

2) *Specify Requirements:* Because the educational materials are designed to accompany the textbook’s explanations, the critical part of the WG’s work was to decide which components should be selected. Furthermore, the course time was considered very short. At the beginning of the WG’s discussion, it assumed that the entry-level education on HCD would be conducted in one or two hours. Therefore, the members tried not to make the contents of the materials too complicated. Also, the members discussed what the participants of the lectures would consider necessary for their studies and their future careers. That is one of the essential points of the WG’s activity in the view of the HCD concept.

3) *Create Design Solutions and Development:* The WG’s process for making the materials was iterative, requiring at least two cycles.

The first cycle started with the prototype of the educational materials for engineers. The product was firstly published in its beta version. The WG then collected feedback and comments at the trial seminars (see Section 4.4). After that, the materials were published as version 1.0, and currently, it has been updated to version 1.1.

The second cycle was based on the first one. The prototype of materials for salespeople was started from the latest version for engineers and then updated according to the WG’s interviews and feedback from trial seminars. It was published as the beta version, and updated to version 1.0, as well.

4) *Evaluate Product:* Evaluation by the potential users is a critical process in the HCD cycle. In the WG’s activities, the members also considered it the principal procedure. As described previously, the WG remained focused on the

evaluation process with the trial events run to evaluate the materials during the design phase.

The WG’s leading work in 2019 was the evaluation, improvement, and investigation of which organizations were utilizing their materials. Several new members, who were users of the materials, joined the WG in 2019. The educational materials and the guidebooks were updated according to the interviews conducted with them and feedback from questionnaires.

*B. Value of the Educational Materials*

The WG aimed to prepare entry-level educational materials and foster instructors who can teach newcomers unfamiliar with the concept of HCD. Therefore, it tried to fill the gap between newbies and experienced engineers, designers, and salespeople by providing the materials.

A review from Amazon’s sales listing of the textbook states that: “It is not easy to understand only by reading. It would be worth reading if some lectures were provided using this book as its textbook.” We had to agree with this comment. Hence, our decision to provide lectures on entry-level HCD knowledge with these materials and guidebooks.

During the work conducted in 2019, the WG collected several opinions and impressions of the products from the new members. All of them mentioned that it was helpful, but there was still some room for improvement. As the materials were provided under the CC license, the users could modify the contents to become suitable for their courses.

VI. EVALUATIONS

We conducted a seminar that introduced the concept of HCD to the office staff who were unfamiliar with it to evaluate the education materials. To perform a subjective evaluation, we asked the participants to fill a questionnaire after the seminar.

The 56 participants answered the following questions.

- How to create awareness for the seminar, their profile, and the knowledge levels of the HCD before participating in the workshop.
- How much did you understand the concept of the HCD?
- How satisfied are you with the seminar?
- The consciousness to learn the HCD more deeply.

*A. The Way to Find the Seminar*

Figure 4 shows the way to find the seminar. It tells us that the HCD-Net actively reached the candidates who should participate in the workshop. Viral communications (friends’ comments in the several SNSs, recommendations from friends and colleagues) are unignorable to disseminate holding events.

As it was an introductory course, it was necessary to disseminate broadly, so “word-of-mouth,” such as recommendations from companies and acquaintances, should be used.

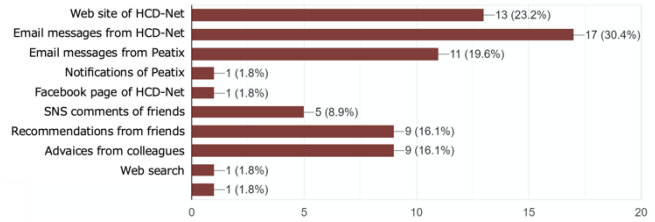


Figure 4. The way to find the seminar.

*B. The Properties of the Participants*

Figures 5 and 6 illustrate the characteristics of the participants of the seminar. The former shows the occupations, and the latter shows the frequency distributions of their generation, which indicates that all working ages are interested in the HCD seminar.

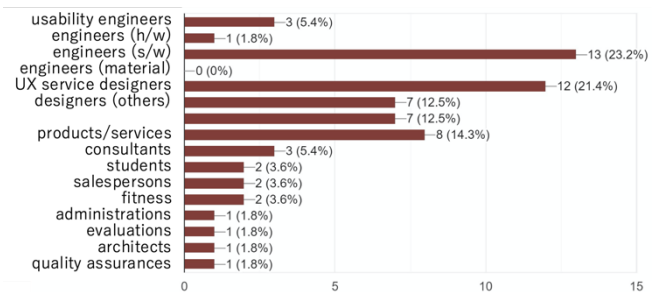
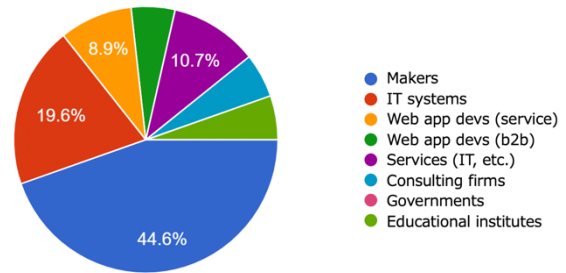


Figure 5. The occupations of the participants.

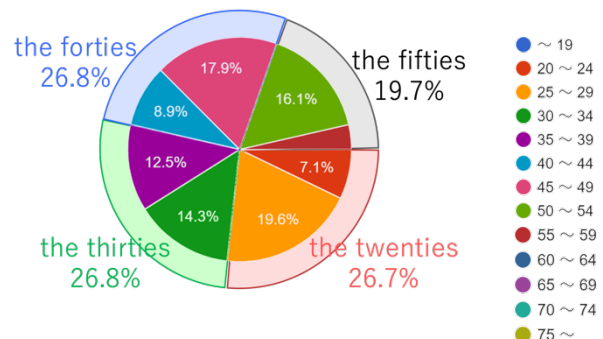


Figure 6. The frequency distribution of participants' generation.

**C. Knowledge Levels of the HCD before Participating in the Seminar**

The participants’ knowledge levels are shown in Figure 7. Approximately one-third, i.e., 32.2% of participants, were estimated as beginners—the seminar’s primary target. Further, 26.7% of participants were practitioners and not directly targeted at this introductory course. However, the results imply that they were interested in online seminars and teaching methods, which would also be meaningful.

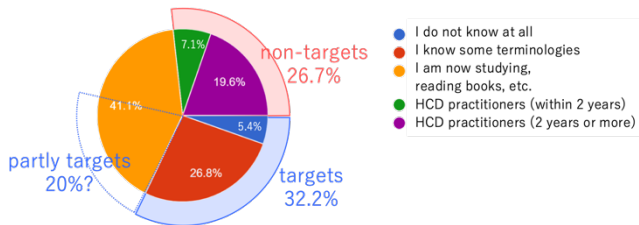


Figure 7. The knowledge levels of the HCD before participating in the seminar.

**D. How Much Did You Understand the Concept of the HCD?**

Figure 8 illustrates the participants’ understanding levels by the categories: the basic knowledge of HCD, users, usability, HCD cycle, and the relation among HCD, design thinking, and UX.

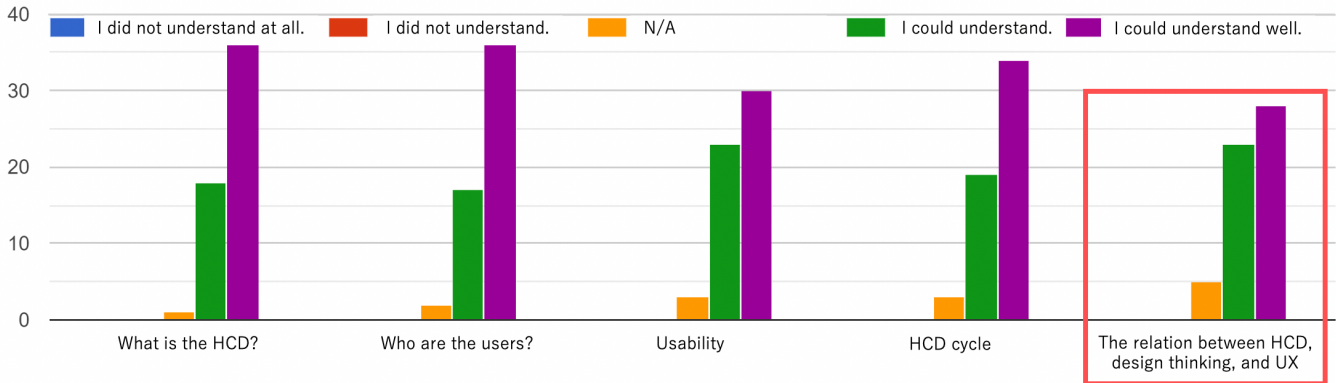


Figure 8. The understanding levels of the participants.

bility, HCD cycle, and the relation among HCD, design thinking, and UX.

For the basic concept of teaching the knowledge of HCD, the seminar should be designed to present HCD issues comprehensively; the results shown in Figure 8 imply that it achieved the goal successfully.

In addition, the answers to the question asking did you understand the relation between HCD, design thinking, and UX showed an excellent score. It was considered that the seminar and educational materials focused on the issues and that it was effective.

**E. How Much Did You Satisfy the Seminar?**

The satisfaction levels of participants by categories are indicated in Figure 9. Apart from the mini work, almost all factors affected the impression of the participants. Significantly, the fact that they were satisfied with the seminar structure and its presentation materials indicates the WG’s deliverables were meaningful and relevant to teach the HCD concept to beginners.

**F. The Consciousness to Learn the HCD More Deeply**

Figure 10 shows the participants’ awareness to learn HCD in depth. The answers varied from level one—which meant they did not have any motivation to learn more—to level five—who had some zeal to learn HCD in depth.

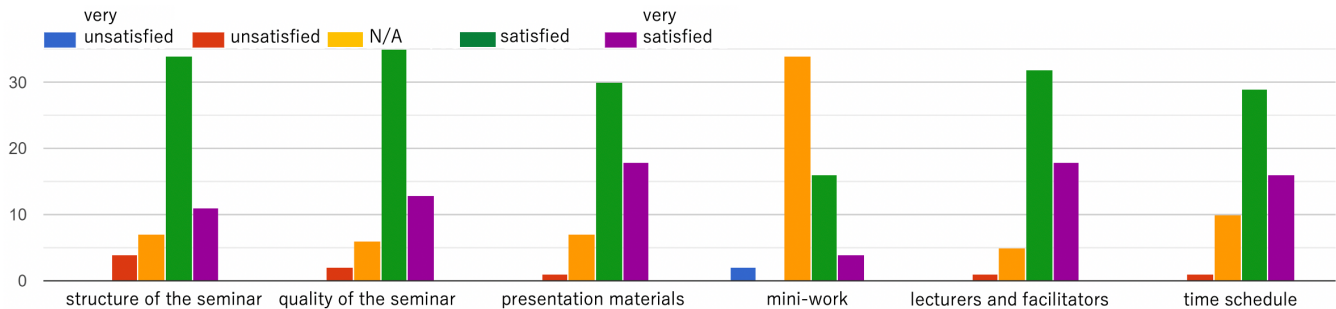


Figure 9. The satisfaction levels of the participants.

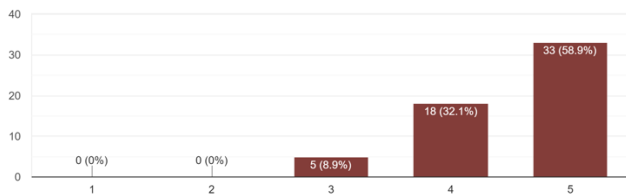


Figure 10. Do you want to learn more about HCD? (from 1 not at all, to 5 very likely)

Figure 10 indicates that the introductory seminar to the HCD was completed, and the participants got a positive impression to learn something deeper about the HCD issues. It also implied that the educational materials the WG delivered had some values to promote the relevance of the concept of the HCD.

## VII. CONCLUSIONS AND FUTURE WORK

The human resource development WG members, which was set up in HCD-Net to implement the entry-level educational materials on HCD and foster lecturers who can train newcomers in each organization, have been working actively during recent years. This paper described their activities and provided an overview of their results. The most significant feature of their work was that their outcomes, that is, the HCD educational materials themselves, were designed according to HCD processes.

The educational materials they created are intended for two different target groups: engineers and salespeople. Firstly, the training materials for engineers were designed. After that, based on the prototype, the revised ones for salespeople were created. Guidebooks for conducting the training were also created to accompany the educational materials to make it easier for the lecturers to present them.

The WG's main activities in 2019 were conducting interviews with the users, delivering questionnaires to them, and improving the educational materials according to the feedback, as described in the last part of Section 4.1. However, a more in-depth analysis of the feedbacks remains to be done as part of their future work.

Several evaluations were performed as part of the HCD cycles in the development processes. We conducted a series of simulated seminars and interviews with users of the prototype versions. After the first publication of those materials, an introductory workshop was held for those unfamiliar with the concept of the HCD. At the end of the seminar, we asked the participants to fill the questionnaire. We analyzed the answers subjectively to evaluate and validate the relevance of the educational materials.

However, the lectures using these educational materials should be more widespread if we let the HCD concepts penetrate all the industries. More and more promotions will be needed, and they remain our future work. Furthermore, more evaluations to improve educational materials should be conducted. It will be an ongoing task as part of the WG's future activities.

## ACKNOWLEDGMENT

The authors thank all WG members and the participants of trial seminars and evaluations, the board members of the HCD-Net, and collaborators for the activities concerning the development of the education materials.

## REFERENCES

- [1] J. Iio, A. Osaki, and R. Waida, "Development and Promotion of Educational Materials on Human-Centered Design," *The Thirteenth International Conference on Advances in Computer-Human Interactions (ACHI2020)*, pp. 447-451, Valencia, Spain & Online, 2020.
- [2] "ISO 9241-210:2019 Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems," <https://www.iso.org/standard/77520.html>, [retrieved: 19<sup>th</sup> Nov 2020]
- [3] Z. Liu, "User Experience in Asia," *Journal of Usability Studies*, vol. 9, no. 2, pp. 42-50, 2014.
- [4] B. B. Hong, E. Bohemia, R. Neubauer, and L. Santamaria, "Design for Users: The Global Studio," *The 20th International Conference on Engineering and Product Design Education (E&PDE18)*, London, UK, 6-7th September 2018.
- [5] H. Yasu *et al.*, "Framework of Education to Promote HCD among Organizations, — Learning from Case Studies —," *Bulletin of Human Centered Design Organization*, vol. 12, no. 1, pp. 13-19, 2016.
- [6] H. Yasu *et al.*, "Framework of Education to Promote HCD among Organizations — Proposal and Evaluation on Action Plans for Each Trainee —," *Bulletin of Human Centered Design Organization*, vol. 13, no. 1, pp. 19-24, 2017.
- [7] R. Waida *et al.*, "Teaching Materials of HCD Introductory Course for Practitioners – Activities of Making the Beta Version," *Bulletin of Human Centered Design Organization*, vol. 14, no. 1, pp. 24-28, 2018.
- [8] A. Kambayashi *et al.*, "Teaching Materials of HCD Introductory Course for Practitioners: Activities of Official Version for Engineers and the Beta Version for People in Contact with Customers," *Bulletin of Human Centered Design Organization*, vol. 15, no. 1, pp. 9-14, 2019.
- [9] "User-centered design," From Wikipedia, the free encyclopedia. [https://en.wikipedia.org/wiki/User-centered\\_design](https://en.wikipedia.org/wiki/User-centered_design), [retrieved: 19<sup>th</sup> Nov 2021]
- [10] J. Ito, A. Ikegami, and T. Hirayama, "Practice of Promoting HCD, Education by a Consumer Electronics Manufacturer," M. Kurosu (Ed.): *Human Centered Design, HCI 2009*, LNCS 5619, pp. 594-600, 2009.
- [11] C. A. Gonzalez, M. Ghazizadeh, and M. Smith, "Perspectives on the Training of Human Factors Students for the User Experience Industry," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 58, no. 1, pp. 1807-1811, 2014.
- [12] M. Vorvoreanu, C. M. Gray, P. Parsons, and N. Rasche, "Advancing UX Education: A Model for Integrated Studio Pedagogy," *Proceedings of the Computer Human Interaction, CHI 2017*, May 6-11, Denver, CO, USA, 2017, DOI: <http://dx.doi.org/10.1145/3025453.3025726>
- [13] C. Wrigley, G. Mosely, and M. Tomitsch, "Design Thinking Education: A Comparison of Massive Open Online Courses," *The Journal of Design, Economics, and Innovation*, vol. 4, no. 3, pp. 275-292, 2018.
- [14] A. Dirin and M. Nieminen, "Relevance of UCD Education to Software Development – Recommendation for Curriculum Design." *Proceedings of the 8th International Conference on Computer Supported Education (CSEDU 2016)*, no. 2, pp. 112-120, 2016.

- [15] M. Adam, S. A. McMahon, C. Prober, and T. Ba'nighausen, "Human-Centered Design of Video-Based Health Education: An Iterative, Collaborative, Community-Based Approach," *Journal of Medical Internet Research*, vol. 21, no. 1:e12128, 2019. DOI: 10.2196/12128
- [16] D. Organ et al., "A systematic review of user-centred design practices in illicit substance use interventions for higher education students," *European Conference on Information Systems 2018: Beyond Digitization – Facets of Socio-Technical Change*, Portsmouth, UK, 23–28 June. 2018.
- [17] J. Carter, Y. J. Bababekov, and M. D. Majmudar, "Training for our digital future: a human-centered design approach to graduate medical education for aspiring clinician-innovators." *npj Digital Medicine*, vol. 1 no. 1, 2018. <https://doi.org/10.1038/s41746-018-0034-4>
- [18] N. Harvey, P. Ankiew, and F. van As, "Fashion design education: effects of users as design core and inspirational source." *Proceedings PATT 37: Developing a knowledge economy through technology and engineering education*, pp. 203–211, Malta, 3–6 June. 2019.
- [19] C. Wilson, W. Bennett Jr., S. Guarino, K. Bove, and T. L. Cain, "Applying a User-Centered Design Approach to Developing Game-Based Training Environments for Aircraft Maintainers," *End-User Considerations in Educational Technology Design*, pp. 217–238, 2018. DOI: 10.4018/978-1-5225-2639-1.ch01
- [20] A. Bowie and F. Cassim, "Linking classroom and community: A theoretical alignment of service learning and a human-centered design methodology in contemporary communication design education," *Education as Change*, vol. 20, no. 1, pp. 126–148, 2016.
- [21] B. Altay, "User-centered design through learner-centered instruction," *Teaching in Higher Education*, vol. 19, no. 2, pp. 138–155, 2014. DOI: 10.1080/13562517.2013.827646
- [22] N. Reich-Stiebert, F. Eyssel, and C. Hohnemann, "Exploring University Students' Preferences for Educational Robot Design by Means of a User-Centered Design Approach," *International Journal of Social Robotics*, 2019. <https://doi.org/10.1007/s12369-019-00554-7>
- [23] K. C. Chen et al., "Creating a Project-based Curriculum in Materials Engineering," *Journal of Materials Education*, vol. 31, no. 2, pp. 37–44, 2009.
- [24] Human Centered Design Organization, "HCD training materials for engineers ver. 1.1," <https://www.hcdnet.org/hcd/column/materials01/hcd-1177.html> [retrieved: 19<sup>th</sup> Nov 2021]
- [25] Human Centered Design Organization, "HCD training materials for salespeople," <https://www.hcdnet.org/hcd/column/materials01/hcd-1307.html> [retrieved: 19<sup>th</sup> Nov 2021]