SERVICE DESIGN FOR PEOPLE WITH DISABILITIES USING CONTEXT-BASED ACTIVITY MODELLING AND INTERNATIONAL CLASSIFICATION OF FUNCTIONING, DISABILITY AND HEALTH

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Abstract

The core of the service is personalization, and personalized should be preceded by an understanding the individual, and the context surrounding the individual. People with disabilities want to use products, and have more services that are just right for him/her. However, since the developer of the product or service is often not the disabled, it is difficult to give insight into the problems of individuals with disabilities. Also, there is a lack of processes and framework in the development of products and services for the disability. Therefore, this paper will propose a framework for service design for people with disability according to Context-Based Activity Modelling (CBAM), Product Service System (PSS) methodology, and International Classification of Functioning, Disability, and Health (ICF) framework. Then the specific process of the kneeling bus for people with disability is explained using the proposed service design framework for people with disability. We hope that this framework for service design for people with disability will become available through much research.

Keywords: Service design, People with disability, Inclusive design, Human behaviour in design, ICF

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1 INTRODUCTION

1.1 Background

The integrated design capability for people-centred value is essential in industry competitiveness as well as in people's living (Kim and Lee 2011). The core of the service is personalization, and personalized should be preceded by an understanding the individual, and the context surrounding the individual. Disability is an umbrella term, covering impairments, activity limitations, and participation restrictions. Impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations. Disability is thus not just a health problem. It is a complex phenomenon, reflecting the interaction between features of a person's body and features of the society in which he or she lives (WHO 2016). There are one billion people in the world suffering from disabilities. Difficulties of living with the disabilities vary from person to person. That is why personalization is more important when making products or services for people with disabilities. People with disabilities want to use products, and have more services that are just right for him/her. However, since the developer of the product or service is often not the disabled, it is difficult to give insight into the problems of individuals with disabilities. Also, there is a lack of processes and framework in the development of products and services for the disability. Therefore, this paper will propose a framework for service design for people with disability according to Product Service System (PSS) methodology and International Classification of Functioning, Disability, and Health (ICF) framework. Then the specific activity of the kneeling bus for people with disability is explained using the proposed service design framework for people with disability.

1.2 Product Service System (PSS)

PSS has been defined as a system of products, services, supporting networks and infrastructure that is designed to satisfy customer needs and to generate values (Goedkoop *et al.* 1999). Creative Design Institute, Sungkyungwan University developed the method to design product-service design concept as well as design support software tools shown in Figure 1 (Creative design institute 2016), and showed real-world case of a small furniture manufacturing firm (Kim *et al.* 2015). The PSS design method is composed of the following steps with corresponding support tools: the Life Cycle Steps (LCS), E3 Values framework, service blueprint, Context-Based Activity Modelling (CBAM), Hierarchical Value Mapping (HVM), design-for-affordance method, and morphological chart method (Kim *et al.* 2015). Experiences are then evaluated in a context-specific manner in real time using the Customer Experience Sampling and Analysis (CESA) method and tool (Kim *et al.* 2011, Kim *et al.* 2015).

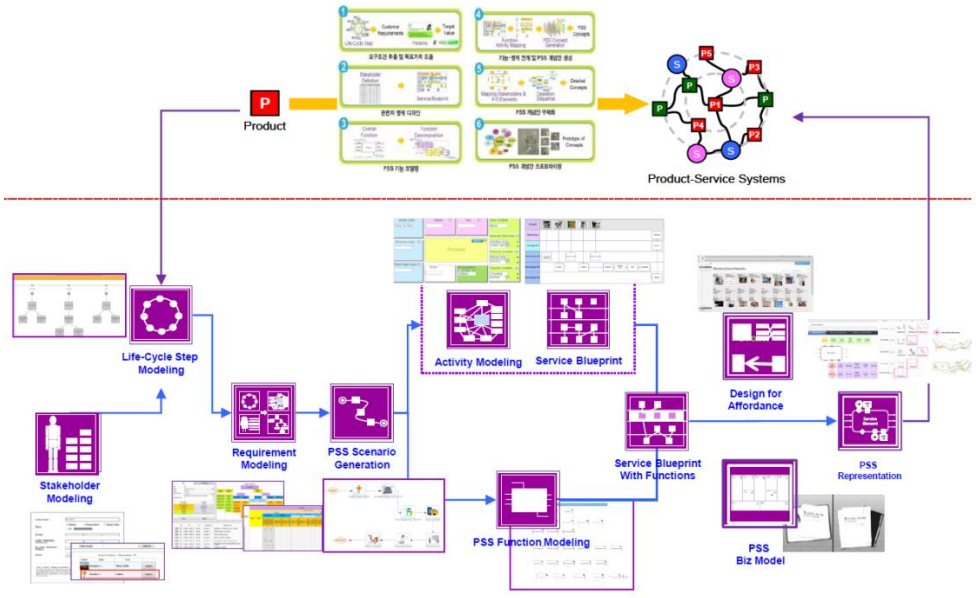

Figure 1. PSS design concept

1.3 Context-Based Activity Modelling (CBAM)

Kim and Lee (2011) introduced the CBAM method and its schematic diagram given in Figure 2. The CBAM is an important step in the PSS process. The CBAM is an essential way to model in detail the behaviour of the user at the AS-IS stage. Also, as a measure of the comparison between the TO-BE and the AS-IS, it is an important step to compare the planning and pre - post changes in the PSS.

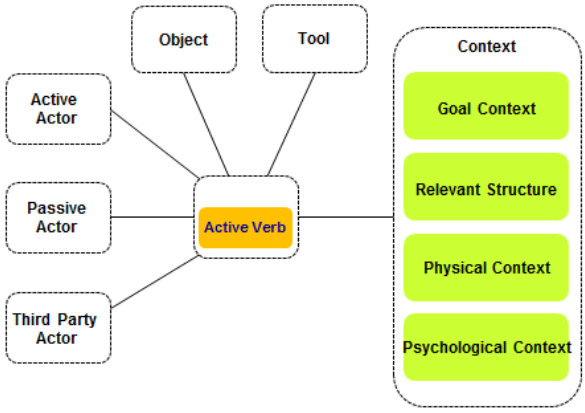

Figure 2. Context-Based Activity Modelling (CBAM)

The activity is described such that the active actor does the action on the object using the tool to the passive actor in the environment with motivation of the event under the context composed of goal, relevant structure, physical and psychological aspects (Kim and Lee 2011). For example, an activity description that "the active actor threw a ball to the passive actor" includes the passive actor in addition to the active actor and the object (Kim and Lee 2011).

1.4 International Classification of Functioning, Disability, and Health (ICF)

In 2001, World Health Organization (WHO) introduced International Classification of Functioning, Disability, and Health knows as ICF in Figure 3. The overall aim of the ICF classification is to provide a unified and standard language and framework for the description of health and health-related states (WHO 2001). ICF is a multipurpose classification designed to serve various disciplines and different sectors, and its specific aims can be summarized as follows: 1) to provide a scientific basis for understand and studying health and health-related states, outcomes and determinants; 2) to establish a common language for describing health and health-related states in order to improve communication between different users; 3) to permit comparison of data across countries, health care disciplines, services and time; 4) to provide a systematic coding scheme for health information systems (WHO 2001).

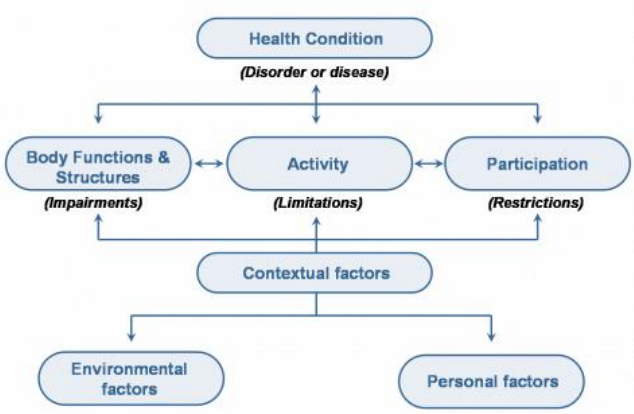

Figure 3. International Classification of Functioning, Disability, and Health (ICF)

The ICF is a set of 595 categories at the second, third or fourth level. The ICF has two parts, Part 1 called ‘Functioning and Disability’ with the two components ‘Body Functions (code b) and Structures (code s)’ and ‘Activities and Participation (code d)’, and Part 2, ‘Contextual Factors (code e)’ with the

two components 'Environmental Factors' and 'Personal Factors' (Schraner *et al.* 2008). 'Functioning and Disability' part in ICF is a good starting place to understand the human user (Cook and Polgar 2014), also 'Activities and Participation' part in ICF explains capacities and difficulties in performance of people with disabilities. Finally 'Contextual Factors' in ICF shows barriers and facilitators. Since ICF was revealed in 2001, there are many researches and practices performed according to ICF. Many researchers have used ICF as a tool of identifying disabilities such as stroke (Geyh *et al.* 2004), spinal cord injury (Cieza *et al.* 2010), chronic conditions (Cieza *et al.* 2004), and childhood disability (Simeonsson *et al.* 2003). Also ICF has been used as a framework by various experts for multi-disciplinary research (Steiner *et al.* 2002, Stucki *et al.* 2002, Schraner *et al.* 2008, Stucki *et al.* 2008, de Gois Pinto *et al.* 2016).

1.5 Human Activity Modelling in Disability Research

Bailey (Bailey 1982) presents the model of human performance. This model is a framework for studying human performance in tasks involving technology, and it is typically employed to describe the performance of a human operator in a given task (activity) within a given situation (context) (Cook and Hussey 2002). When a person with a disability is faced with an activity in a given context, he may require assistive technologies to facilitate his performance (Cook and Hussey 2002). Cook & Hussey (2002) created Human Activity Assistive Technology (HAAT) model shown in Figure 4 (left) from Bailey's model. There are two changes. First, the context is broadened to include social, cultural, environments and physical conditions. Second, assistive technologies and related services to compensate disability functions are specifically show, and their relationship to the other three components is illustrated.

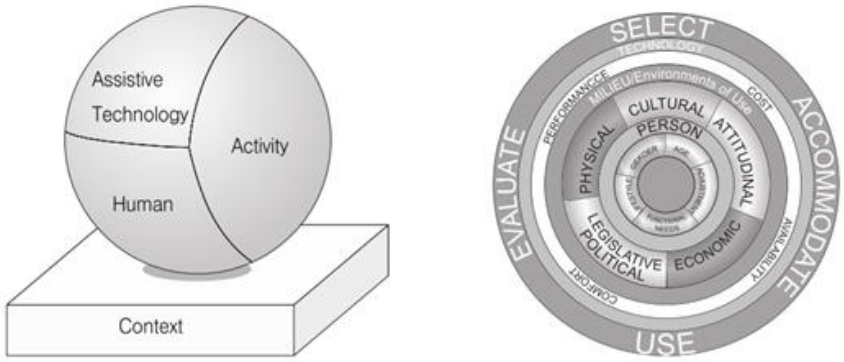

Figure 4. Human activity modelling; HAAT (left), and MPT (right)

The disability experience is an interactive one. That is, an alteration in one ICF component influences each of the others. This interrelationship is shown in Figure 4 (right). The Matching Person and Technology (MPT) Model, as shown in this diagram, with assistive technology as the example, occurs within and requires assessment of the Context of Environmental and Personal Factors in ICF (Scherer and Dicowden 2008). The MPT model utilized the ICF to interpret components of disabilities.

2 ICF-CBAM FRAMEWORK

2.1 The Overall ICF-CBAM Framework

The activity is described such that the active actor does the action on the object using the tool to the passive actor in the environment with motivation of the event under the context composed of goal, relevant structure, physical and psychological aspects (Kim and Lee 2011). The active actor in CBAM can add the body functions and structures of the ICF to the existing description. Also we can refer 'activity and participation' in ICF to the activity and event in CBAM. Lastly, 'Contextual factors (Environmental factors and Personal factors)' in ICF are corresponding to the context part including object, tool, and environment in CBAM.

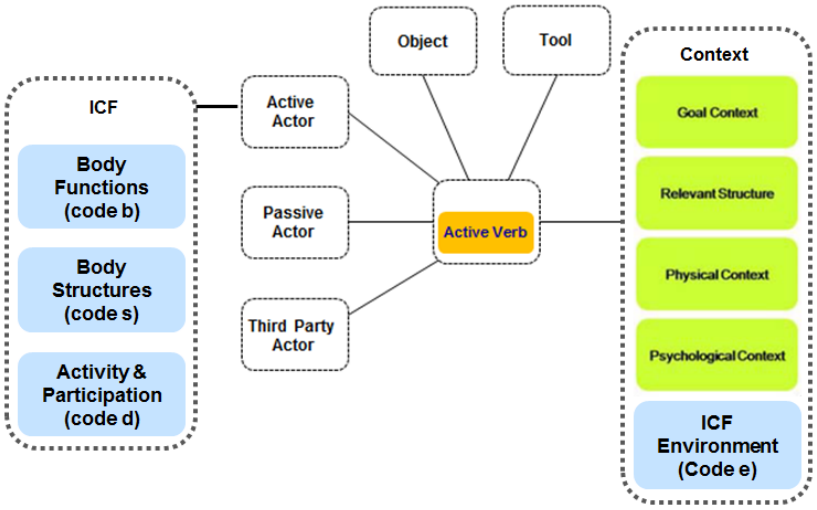

Figure 5. ICF-CBAM Framework

2.2 Step by Step Application of ICF-CBAM in PSS

2.2.1 Indicating current situation

The ICF-CBAM in Figure 5 can be used as a tool to describe the current situation. For example, the active actor (with ICF code b, s) does the action (code d) under the context composed of goal, relevant structure, physical and psychological aspects, and ICF contextual factors (code e). 'Activity and participation (code d)' can be measured 2 categories such as performance and capacity in ICF, and each category is measured from 0 point to 4 point.

A system can be defined very generally as consisting of a group of objects that can interact with each other and are assembled in a way intended to achieve a desired goal (Cooper and McGillem 1967). The ICF-CBAM can be used as an indicator of the current situation along with customer journey map in PSS. Improvements in PSS can also be reflected in the flow of ICF-CBAM in Figure 6.

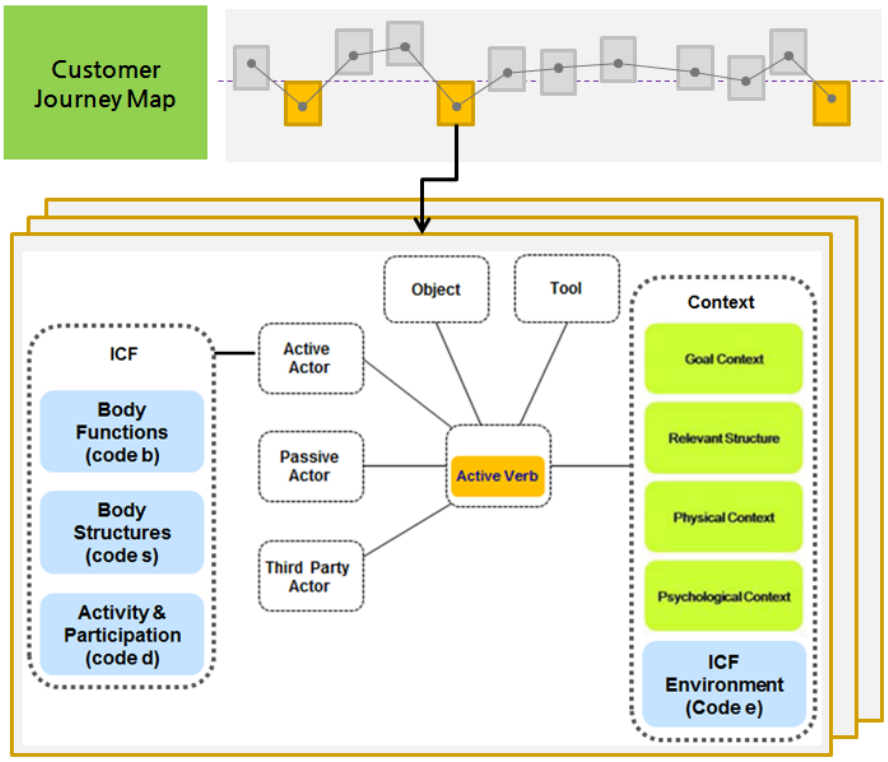

Figure 6. ICF-CBAM with customer journey map

2.2.2 Showing changes and checking outcomes (pre-post evaluation)

The performance is the current state, and capacity is the future state where the product and service (tool and context) is improved. 'Contextual factors (code e)' in ICF are divided into 5 categories: 1) Products and technology, 2) Natural environmental and human-made changes, 3) Support and relationships, 4) attitudes, 5) Services, warranties, and policies. 'Code e' in ICF is measured from barriers (-4 ~ 0) and facilitators (0 ~ +4). Changes of the products and services after service design project can be measured from comparing AS-IS to TO-BE in Figure 7.

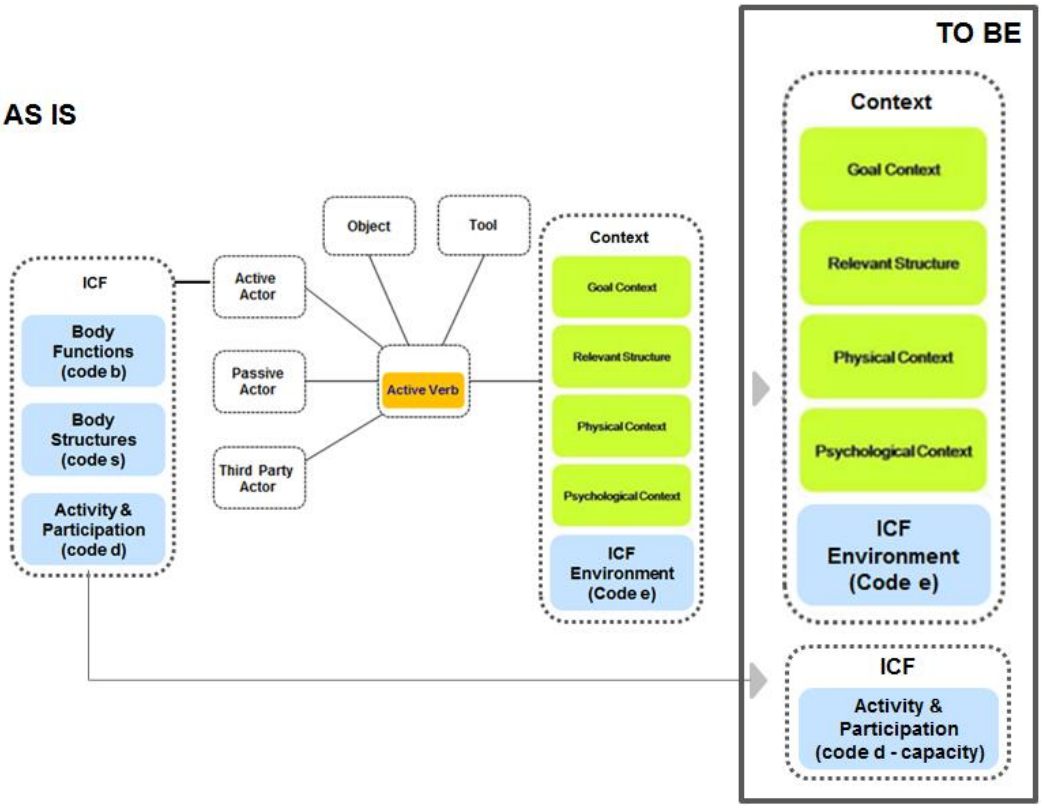

Figure 7. ICF-CBAM as a tool of outcome measurement

3 CASE STUDY: PSS DESIGN FOR THE KNEELING BUS

3.1 People with Spinal Cord Injury and the Kneeling Bus

Spinal cord injuries are caused by traffic accidents, falls, etc., and as a result, they suffer from paralysis and other disorders. The Brief Core Set included a total of 33 second-level categories with 9 on body functions, 4 on body structures, 11 on activities and participation and 9 on environmental factors (Cieza *et al.* 2010) shown in Table 1. People with spinal cord injury find difficulties moving indoor and outdoor due to the lack of function in legs, they often use wheelchair. If you use a wheelchair, it becomes difficult to use public transportation such as buses with stairs. The kneeling bus was developed for a person who feels uncomfortable to move in daily life, such as the disability, the elderly, women in pregnant, and a person accompanying infants or children. Minimizing the steps between buses and bus station eliminates physical barriers for wheelchair users to climb on the bus. Currently, 40% of buses in Seoul, Korea are kneeling bus.

Despite the existence of the kneeling buses, most of the wheelchair users had difficulty in using the kneeling buses. The following are the reasons why wheelchair users are having trouble getting on the bus according to the yearly report (ministry of land 2015) and in-depth interview; a bus doesn't stop at the bus stop properly, the failure of taking off the ramp, the lack of bus driver education, and bus passengers don't consider wheelchair user. Wheelchair users sometimes give up riding a bus when there are many people on the bus during commute times. Despite the elimination of physical barriers with the kneeling bus, there is psychological barrier due to the lack of communication between bus driver, bus passenger, and wheelchair user.

Table 1. ICF categories included in the Brief ICF Core Set for spinal cord injury

ICF component	*Rank*	*ICF code*	*Title*
Body functions	1	b730	Muscle power functions
	2	b620	Urination functions
	3	b280	Sensation of pain
	4	b525	Defecation functions
	5	b640	Sexual functions
	6	b810	Protective functions of the skin
	7	b735	Muscle tone functions
	8	b710	Mobility of joint functions
	9	b152	Emotional functions
Body structures	1	s120	Spinal cord and related structures
	2	s610	Structure of urinary system
	3	s810	Structure of areas of skin
	4	s430	Structure of respiratory system
Activities and participation	1	d530	Toileting
	2	d420	Transferring oneself
	3	d230	Carrying out daily routine
	4	d465	Moving around using equipment
	5	d410	Changing basic body position
	6	d445	Hand and arm use
	7	d470	Using transportation
	8	d455	Moving around
	9	d520	Caring for body parts
	10	d550	Eating
	11	d240	Handling stress and other psychological demands
Environmental factors	1	e310	Immediate family
	2	e120	Products and technology for personal indoor and outdoor mobility and transportation
	3	e115	Products and technology for personal use in daily living
	4	e150	Design, construction and building products and technology of buildings for public use
	5	e155	Design, construction and building products and technology of buildings for private use
	6	e110	Products or substances for personal consumption
	7	e355	Health professionals
	8	e340	Personal care providers and personal assistants
	9	e580	Health services, systems and policies

The activity of wheelchair users using the kneeling bus is shown in Figure 8: 1) he/she leaves home, 2) waits for the bus at the stop, 3) gets on the bus, 4) rides in wheelchair-only seat in the bus, 5) secures with safety device, 6) gets off the bus when arriving to the designated bus stop, 7) and finally moves to the destination. Among these activities, several reports and in-depth interview tells that the problem of using the kneeling bus is on the activity of 3) getting on the bus and 4) riding in wheelchair-only seat in the bus.

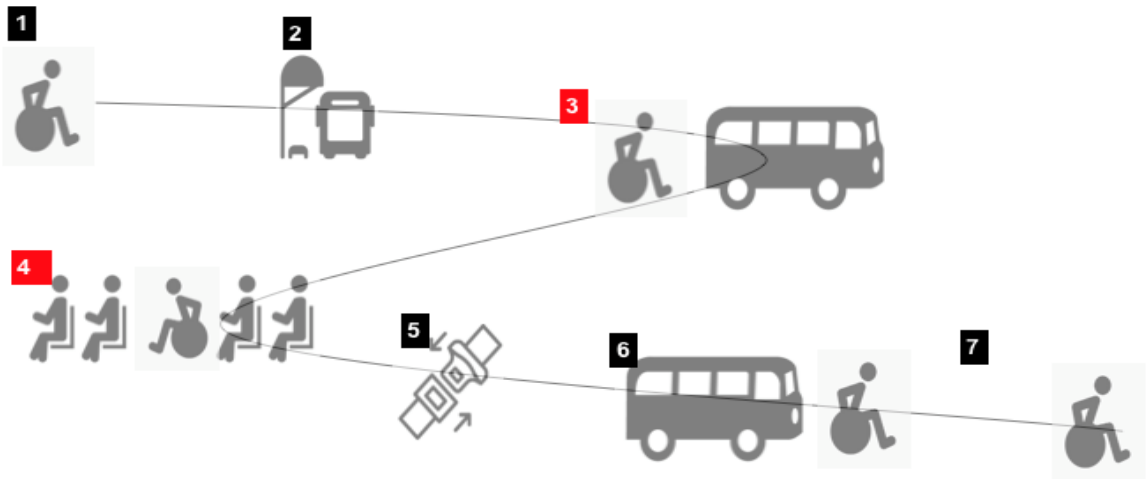

Figure 8. Customer journey map of riding a kneeling bus for wheelchair user

3.2 ICF-CBAM for the Kneeling Bus Experience for People with Spinal Cord Injury (AS-IS)

The ICF-CBAM of activity 3) getting on the bus is shown in Figure 9 (left). Wheelchair user (b730.4: muscle power functions - 4, s120.4:spinal cord and related structures -4, d420.P4:Transferring oneself - 4, d470.P4:Using transportation -4) does the action (riding on the bus) under the context composed of goal (riding on the bus), relevant structure, physical (rainy day, and commute time) and psychological (alone, and complicated) aspects, and ICF contextual factors (e120.-3: products and technology for personal indoor and outdoor mobility and transportation - minus 3, e340.-3: Personal care providers and personal assistants - minus 3). While a wheelchair user wants to ride a bus, a bus driver sometimes does not know that the wheelchair user is waiting for a bus and may not be able to stop in place. If this is solved, it will have the effect of lowering the psychological impediment of the wheelchair user waiting for buses.

The ICF-CBAM of activity 4) riding in wheelchair seat in the bus is shown in Figure 9 (right). Wheelchair user (b730.4:muscle power functions -4, s120.4:spinal cord and related structures -4, d420.P4:Transferring oneself -4, d470.P4:Using transportation -4) does the action (sitting on the chair) under the context composed of goal (sitting on the chair), relevant structure, physical (commute time, in the bus) and psychological (alone, and complicated) aspects, and ICF contextual factors (e120.-3: products and technology for personal indoor and outdoor mobility and transportation - minus 3, e340.-3: Personal care providers and personal assistants - minus 3). After the wheelchair user rides on the bus, he tries to sit in a wheelchair-only seat. However, the wheelchair user needs to tell the passenger to mover away if the passenger is already sitting there. Now, the bus driver is asking to the bus passenger to give up his seat through the microphone in the bus. If the bus driver recognizes that the wheelchair user is waiting in advance and notifies the bus passenger through various media including light, sound, and pre-recorded video how to help, the bus passenger will be able to prepare the wheelchair-only seat for the wheelchair user. Bus passengers would be eager to help the wheelchair users for the wheelchair-only seat, but they may have difficulty folding their seats or moving out of their seats because they do not know how to help. At this time, it is possible to previously announce folding the wheelchair-only seat through the pre-recorded video in the bus. In addition, if the default setting of a wheelchair-only seat is folded, bus passengers may not sit down and wheelchair users may be more likely to sit.

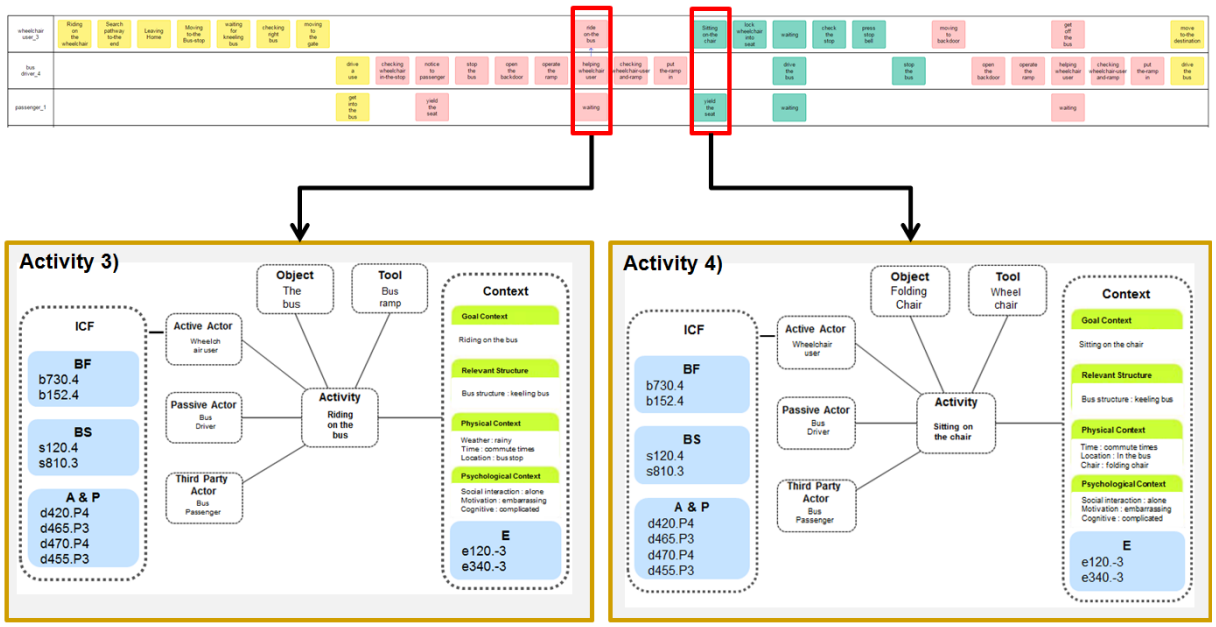

Figure 9. ICF-CBAM on activity 3) and 4)

3.3 TO-BE Prototype and ICF-CBAM of the Kneeling Bus

While a wheelchair user waiting for the bus, he can tell the bus driver that he is waiting in the bus stop (Figure 10. 1-1). As soon as the bus driver knows that the wheelchair user is waiting and informs the bus passenger in a variety of ways including light, sound, and vibrating the chair (Figure 10. 2-1, 2-2) and showing pre-recorded video how to help a wheelchair user sitting on the chair (Figure 10. 2-3).

These devices (Figure 10. 2-1,2-2,2-3) should be designed to reduce driver's physical burden, bring down passenger's psychosocial barriers helping a wheelchair user, and lower the psychological anxiety or shame of wheelchair users.

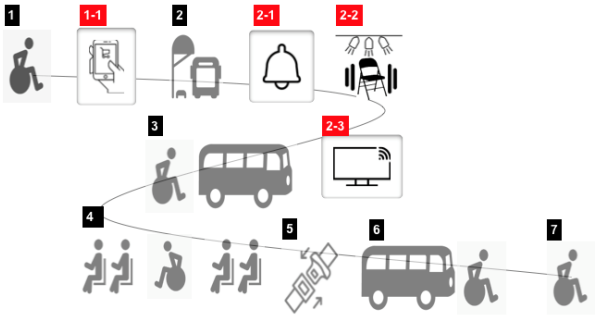

Figure 10. TO-BE Customer journey map of the kneeling bus

Psychological context in Figure 11 can be improved through the prototype of Figure 10. This may improve 'Activity & Participation' and 'environmental factor' score in ICF. The ICF-CBAM can be used as a framework to present the results of service design.

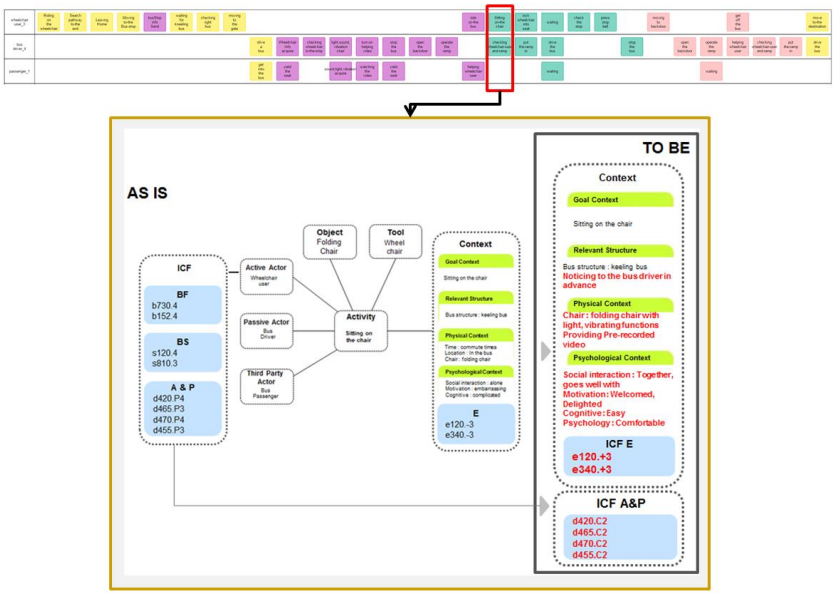

Figure 11. TO-BE ICF-CBAM on activity 4)

4 SUMMARY AND FUTURE RESEARCH

In this paper, the ICF-CBAM framework for service design for people with disability according to PSS methodology and ICF framework was proposed. Then the specific activity of the kneeling bus for people with disability was explained using the ICF-CBAM framework. Several studies (Cieza *et al.* 2004, Cook and Polgar 2014, de Gois Pinto *et al.* 2016) have suggested a human activity modelling for the development of products for people with disability, but no systematic framework for PSS using ICF has yet been proposed. In addition, we suggested dynamic framework according to the change of time series by linking with service blueprint. ICF was able to provide a tool for PSS outcome measurement. As activities are the key in service design, the proposed ICF-CBAM can play a central role in PSS process for people with disabilities. It is also expected that there will be active exchanges with expert groups in developing products and services for people with disabilities through using ICF-CBAM. The limitation of this study is that the pilot test was not yet performed for this case study. We will use the ICF-CBAM in various studies as well as the pilot test in the future, and hope that this ICF-CBAM framework will become available through much research.

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