The Idea Generation Process for Support Tools Enhancing Pedestrian Experience of the Mobility Handicapped in Smart City

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***Abstract*— The objective of this paper is to develop ideas for support tools of the mobility handicapped. As the smart city is under the spotlight based on the information and communication technologies, development of support tools for the mobility handicapped has a chance to go forward in advanced using the technologies of the smart city. There were several researches to develop support tools for the mobility handicapped, but most of them focused mainly on the walkability. This paper suggests the process to develop ideas of the support tools to enhance holistic Pedestrian eXperience (PX). The process was helpful in developing ideas for support tools especially for the mobility handicapped in this study. The process consists of seven steps, and description and outcomes of each step will be presented.**

Keywords-Pedestrian Experience; Support tools; Idea generation; PX principles; The mobility handicapped

I. INTRODUCTION

Ramp and handrail on the sidewalk are the typical tools for people who have a problem on mobility. The people who need help on mobility are called the mobility handicapped [1]. The mobility handicapped can be classified by their duration of handicap; the temporary mobility handicapped and non-temporary mobility handicapped. The non-temporary mobility handicapped includes the disabled, the aged, and a child [2]. The temporary mobility handicapped includes a pregnant woman, an injured person, and a person with luggage [2]. If we consider this broad definition of mobility challenges, it is obvious that anyone can confront mobility challenges at least temporarily. Therefore, mobility challenges should be considered as one of the most important parts of social welfare service now.

So far, a variety of support tools have been developed based on information and communications technology (ICT) to help vulnerable pedestrians [3]. With the emergence of smart city, which means that public infrastructures are connected and communicate with each other based on the ICT, expectations on its positive benefits are escalating [4][5]. Everything can be digitalized through the sensors built in the formerly analog infrastructures. Various organizations can provide services to the citizen using the public data. Because of the rapid advance in scientific technology, the smart city can become an important part of our life. Smart city has been studied in various fields; "Natural resources and energy," "buildings," "government," "economy and people," "Transport and mobility," and "livings" [4]. The last two fields are related to the mobility handicapped. It can be a great chance to develop effective and efficient support tools for the mobility handicapped using the public data.

Despite the potential of smart city to provide a variety of support tools for the mobility handicapped, few studies were found that considered the problems and needs of the mobility handicapped systematically. Due to the lack of empathetic understandings of user needs, most of them focused mainly on walkability such as the ease and safety of walking, ignoring such factors as affective or social aspects of pedestrian experience.

This study suggested the systematic process to develop idea on effective and efficient support tools for the mobility handicapped based on their own needs and problems. We borrowed the UX concept to find out the factors outside of ease and safety.

UX is an experience that consists of all aspects of users' interactions with a certain product or service [6]. The paradigm of UX is shifted to the pedestrian environment from the electronic devices. This paper defines the concept of Pedestrian eXperience (PX) as "pedestrian cognition, affect, behavior occurred from the interaction with a pedestrian passage and its' related environment in a specific context." Fig. 1 presents conceptual framework of PX.

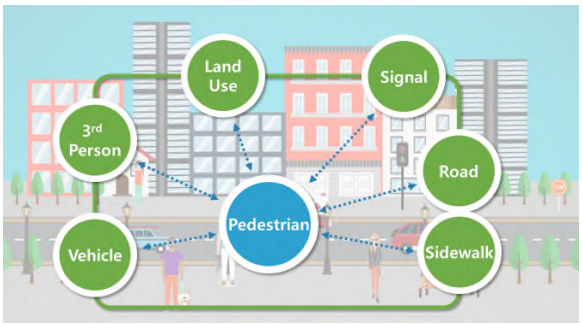

Figure 1. Conceptual Framework of PX

This paper focused on the non-temporary handicapped; the disabled, the aged, a child. The non-temporary mobility

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handicapped might have more problems and needs than temporary one. The problems and needs in the walking situations were considered in this paper. According to the Korean Ministry of Land, when the mobility handicapped travel, they mostly use sidewalk than the other transport systems [7]. Therefore, the infrastructure that is the most urgent to be improved is sidewalk [8].

In Section 2, existing studies about pedestrian experience and support tools are introduced with their limitation. Section 3 describes the overall process of the idea generation. The results of the complete process are also presented. In Section 4, the significance of the suggested process is explained.

II. LITERATURE REVIEW

The existing studies related to PX and support tools for the mobility handicapped are introduced in this section. The necessity of this research is understandable from the limitations of the existing studies.

A. *Literatures related to Pedestrian eXperience (PX)*

Most literatures related to PX deal with pragmatic factors such as walkability and safety significantly rather than hedonic factors such as affect and sociability. Park considered five factors of walkability; “sense of safety,” “sense of security,” “comfort,” “convenience,” “visual interest”. He only considered visual interest as a hedonic factor of the pedestrian environment that is vague [9]. Lo suggested Portland pedestrian planning parameters [10] with 7 factors, but he did not consider hedonic factors at all. Ewing suggested 9 principles, but he also focused on pragmatic factors with only one hedonic factor, tidiness [11].

Kari suggested 5 factors including social related factor [12]. He suggested pragmatic factors; “safety,” “comfort and convenience,” “functional characteristics,” and hedonic factors; “aesthetics,” “social characteristics”. Although he suggested well-balanced factors between pragmatic and hedonic, he did not answer what the aesthetic factor means sufficiently. He only considered attractiveness and visual condition of the environment as detailed factors of aesthetics that are vague. The experts of the User eXperience (UX) can suggest specific hedonic factors that affect PX borrowing the UX concept.

B. *Literatures related to support tools for the mobility handicapped*

The literatures related to support tools for the mobility handicapped usually focus only on the walkability and safety using robotic system. For example, Ni et al. developed robotic system that guides and enables the visually impaired to avoid obstacle on the road [13]. Fontanelli et al. suggested guidance mechanism for a walking robotic assistant [14]. Jiang et al. also developed motion algorithms of walking-assistant robot [15]. There were other researches that utilized mobile and smart devices to assist the mobility handicapped. Scheggi et al. developed a vibrotactile bracelet that gives directional cues to the aged [16]. Miller developed walking assistant application of smartphone that recognizes an object on the road and let the pedestrian know the object and its’ direction [17].

However, the mobility handicapped also have the problems in the outside of the walkability and safety. The hearing impaired, who does not seem to be a disabled, can be embarrassed when a stranger asks a passerby for directions. It can lead low sociability of the mobility handicapped. It is essential to find out what the mobility handicapped have problems regarding PX. Also, the researches usually have been focused on the visually or physically impaired or aged. It was relatively hard to find the researches for improving PX of the hearing impaired or a child.

III. SUGGESTION OF THE IDEA GENERATION PROCESS

This study suggests the process of generating support tool ideas that improve PX of the mobility handicapped. The key point of the process is to consider experience of the pedestrian. We do not only focus on the walkability, but considering whole experiences on the road. The process we suggest includes 7 steps (Figure 2). Detailed explanations of each step are described below.

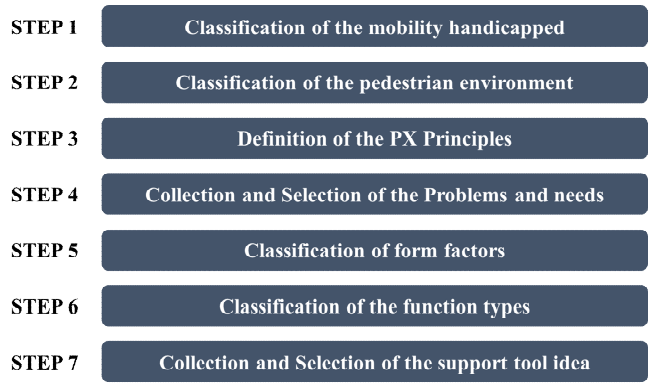

Figure 2. Seven steps of the idea generation process

A. *Step 1: Classification of the mobility handicapped based on their walking characteristics*

The walking characteristics of the mobility handicapped are figured out based on the physical/cognitive/behavioral characteristics of them. We can classify the types of the mobility handicapped based on their walking characteristics, not the demographic factors. The results can be utilized when defining “who” has problems and needs in step 4.

The literature survey was conducted to find out the walking characteristics of the mobility handicapped; the visual/hearing impaired, physically challenged person, mentally handicapped, the aged and child. The literature about physical/cognitive/behavioral characteristics of the mobility handicapped were also collected, and walking characteristics were inferred from them. Also, interview was conducted. 9 participants who works for the mobility handicapped were recruited, and they told us the walking characteristics of the mobility handicapped.

We could define the types of the mobility handicapped based on the walking characteristics, not the demographic factors. The results would let us focus on the unusual

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walking characteristics that can leads problems and needs, not being restricted to a specific type of the mobility handicapped. The 34 pedestrian characteristics of the mobility handicapped were deduced from the physical, cognitive, and behavioral characteristics of the mobility handicapped (Table 1). The 34 pedestrian characteristics were classified into 15 categories.

Walking characteristics could be helpful to understand the mobility handicapped, which make us generate contexts of the problems and needs easily in the step 4. Combining with the PX principles and pedestrian environment, the contexts of the problems and needs will be better specified.

B. Step 2: Classification of the pedestrian environment

The spaces of the pedestrian environment were classified, and the related objects were arranged. Furthermore, time related factors were also considered to generate more various ideas. The results can be utilized when defining "where and when" the problems and needs happened in step 4.

The literature survey was conducted to collect the elements of the pedestrian environment. The collected elements were classified through the open card sorting. The field observation was also conducted to supplement the lists of the elements of the pedestrian environment. 87 Pedestrian environment's elements were arranged as 8 spaces (Table 2).

The human/animal, weather, and time related elements were also considered through the brainstorming to generate various ideas in step 4. The mobility handicapped can have a variety of problems and needs depends on the weather and time. Also, they can have a trouble when interacting with other people and animals.

TABLE I. THE PEDESTRIAN CHARACTERISTICS OF THE MOBILITY HANDICAPPED

The pedestrian characteristics of the mobility handicapped
The eye height is lower than the non-mobility handicapped
Walking speed is slower than the non-mobility handicapped
Easy to trip and fall to the ground
Difficult to communicate with others
Using means of assistance for walk
Difficult to acquire the information about surrounding envirnment
Relying on the non-visual sensation when walking
Having unsafe walking & crossing habit
Difficult to use devices while walking
Difficult to avoid approaching objects and obstacles
Necessary to get a great deal of rest while walking
Difficult to walk outside on rainy and snowy days
Difficult to walk on the low accessibility environment
Physical/Cognitive disabilities appear to the third person
Physical/Cognitive disabilities do not appear to the third person

TABLE II. CATEGORIES OF THE PEDESTRIAN ENVIRONMENT

Categories	Sub-categories
Space	Exclusive pedestrian road
	Community road
	Exclusive vehicle road
	Crosswalk
	Pedestrian overpass/underpass
	(Bus/Taxi) Stop
	Subway station
	Park
Human/Animal	Fellow traveler
	Third party
	Crowd
	Animal
Weather	Spring
	Summer
	Autumn
	Winter
Time	Day-time
	Night-time

C. Step 3:Definition of the PX Principles

The PX principles means the recommended design rules of every system that enhance the pedestrian experience. This can be the classification standard of the pedestrian's problems and needs. The PX principles do not only consider walkability. Affects, safety, and sociability are also considered to improve the satisfaction of pedestrian experience. The results can be utilized when defining "why" the problems and needs happened in step 4.

The literature survey was conducted in the UX and PX fields. PX includes walkability concept. The most of the PX literature were related to walkability. 24 UX literatures and 7 PX were collected, and three results of the previous project of the researcher's organization were also utilized. Open card sorting was conducted to categorize principles, and brainstorming of UX experts was conducted to supplement the PX principle.

There were 6 principles categorized as "walkability", 6 as "affect", 4 as "safety," and 4 as "sociability". PX principles can be utilized to find out overall problems and needs on walking experience that are not only bounded on walkability. The defined principles were checked if the problems and needs of the mobility handicapped are matched with each principle (Table 3).

TABLE III. PX PRINCIPLES

Category	Explanation
Walkability	The pedestrian environment should be designed to let pedestrian use elements of pedestrian environment easily and comfortably
Affect	The pedestrian environment should be designed to let pedestrian satisfy affective desire
Safety	The pedestrian environment should be designed to make pedestrian safety from the hazard
Sociability	The pedestrian environment should be designed to make pedestrian being sociable

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Problems and needs were collected through the interview with 9 workers related to the mobility handicapped. From the interview, “friendliness” was added in the affect principle.

D. Step 4: Collection and Selection of the Problems and needs of the mobility handicapped

The problems and needs of the mobility handicapped are figured out in this step. The results of the steps 1-3 are utilized in this step to find out specific contexts of the problems and needs.

Two major methods can be utilized in this step. First method is focus group interview (FGI) with the mobility handicapped. From step 1 to 3, we have acquired the characteristics of the mobility handicapped through literature surveys and interviews with workers related to the mobility handicapped such as social worker and kindergarten teacher. It is essential to meet the mobility handicapped directly to understand them deeply.

Second method is ‘Morphological Analysis (MA)’ that let us to consider almost every possible context of problems and needs. The results of the step 1-3 is utilized in MA (Figure 3). Based on the two methods, problems and needs of the mobility handicapped on walking are figured out.

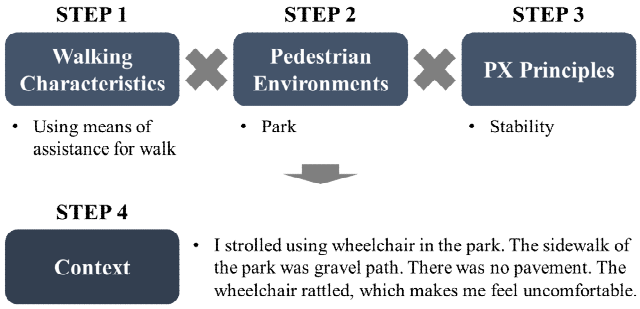

Figure 3. Process flow diagram of Step 1-4

E. Step 5: Classification of form factors

The form factors of a support tool are considered in this step. Possible candidates are investigated, and classified. The list of the form factors is utilized when considering “what” solves a problem in step 7.

There are several types of products that are called “form factors”. Form factors can be utilized to implement functions such as receiving information and giving services to the pedestrian using ICT.

The products in the pedestrian environments can be considered as form factors such as traffic lights/signs, street lamps. The products possessed by pedestrian also can be utilized to develop support tools such as smart phone, watch, glasses. The lists of the form factors can be collected by literature survey and experts’ in-depth interview.

F. Step 6: Classification of the function types

The function types are considered in this step. The list of the function types is utilized when considering “how” to solve a problem in the ideation step like form factors.

As there are several types of products, there are several function types. The lists of the function types can be constructed by the literature survey and brainstorming. Alarm is representative function type of the support tool. It is usually used when people need to be noticed. Diagnosis is another function type that is usually used when people want to know the overall condition of a system. A game can also be another function type, which can be used to educate people with fun.

G. Step 7: Collection and Selection of the support tool idea for the mobility handicapped

The specific support tool ideas are developed in this step. The results of steps from 4 to 6 are utilized for the ideation process (Figure 4). The ideas can be constructed by the context of problems and needs, form factor, and function type.

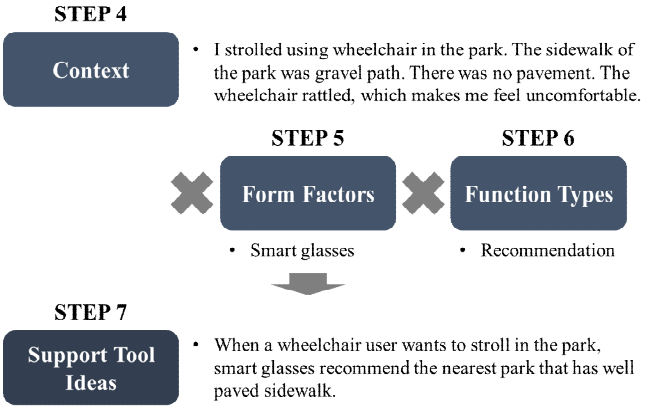

Figure 4. Process flow diagram of Step 4-7

The results of the steps 4-6 can be utilized in this step using ‘MA’. MA can be a powerful tool to develop various ideas. Combination between contexts, form factors, and function types would lead us to consider every major problems and needs.

Another ideation tools can be used in this step such as brainstorming and TRIZ to supplement the idea sets from MA. After ideation, high quality ideas should be selected using specific standards such as feasibility, creativity, effectivity using analytic hierarchy process (AHP).

Ideas that have high relation with each other can be grouped to be developed in the one product. For example, there can be integrated recommendation service that would guide one to the nearest well paved park.

IV. DISCUSSION

The suggested systematic idea generation process includes MA, which can allow us to consider as many contexts as possible. Although user research is conducted, the problems and needs that the users do not recognize by themselves cannot be considered. MA is effective methodology to generate users’ potential problems and needs.

This process emphasizes PX that includes not only pragmatic perspectives but also hedonic perspectives such as affect and sociability of the pedestrian. The existing studies in Section 2 only focused on the pragmatic perspectives, which is considered as more critical issues than hedonic ones.

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However, after UX concept had emerged in the electronic device field in the 21st century, affect and sociability also became an important part of the products and services. In contrast, affect and sociability of the mobility handicapped are rarely considered in the pedestrian environments. Regarding PX principle as a factor of MA, idea designer can think outside the box and generate creative support tool ideas.

Design thinking refers to "a methodology used by designers to solve complex problems, and find desirable solutions for clients" [18]. The process of the design thinking consists of divergent and convergent thinking. The suggested systematic idea generation process can be a kind of design thinking process, which highlights divergent thinking. Adopting MA and emphasizing PX, Divergent thinking can be conducted more actively (Figure 4). Quantitative and qualitative improvement of the idea generation is expected simultaneously.

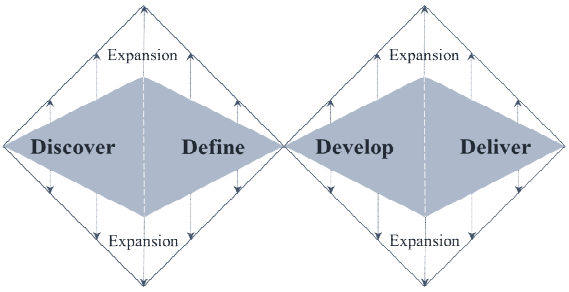

Figure 5. Double diagram of design thinking process

The idea generation process has not been completed yet. The steps 1-3 have been finished, and the step 4 is now in progress. The steps 5-7 are going to conducted. After conducting the all steps, the lists of the all problems and needs can be utilized as the data base, each can be a topic of the basic research of the mobility handicapped. Likewise, each support tool idea can also be utilized as a topic of the development research.

V. CONCLUSION

This paper suggested the process for generating ideas of support tools to enhance pedestrian experience of the mobility handicapped. Defining the principles that covers various aspects of pedestrian experience helped us explore support tool ideas beyond walkability. We hope the results of this study can contribute in making the world one step closer to an equitable society. It is also expected that the suggested process can give insights to other researchers who try to develop ideas of support tools in the other domains as well.

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