Protocol Study of Participatory-Action Research: Developing an Appropriate Assistive Technology Device for People with Disability and the Elderly

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INTRODUCTION

Appropriate technology is that which fit local conditions and can be easily and economically utilized from readily available resources by local communities to meet their needs. These technologies can be modified using the network of the local society that combines existing technologies without disrupting the existing system to meet the demands of the developing society(1). The use of an appropriate technology is required in Korea to develop assistive technology devices that are difficult to commercialize using conventional product development methods because of the small target population and high development and production costs.

Figure 1. Assistive Technology Openlab

Therefore, the Assistive Technology Openlab (AT Openlab) was set up at the National Rehabilitation Center (NRC) in Korea to develop assistive technology devices using an appropriate technology which is shown in Figure 1. The AT Openlab was set up as a makerspace, which applied universal design that allows access to the elderly and those with disabilities. Through research and development (R&D) of the appropriate assistive technology (AAT) devices based on the user demand and usability test, the information, design drawings, and usage guidelines on AAT devices formulated by the manufacturers are shared and supported, and equipment, manpower, space, and educational support are provided for R&D of AAT(2). However, in reality, an insufficient number of cases exist in which the elderly and those with disabilities participated in the development and usability test or in which appropriate research protocol was used during the development of AAT devices in the makerspace.

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Therefore, a protocol is necessary that ensures safety during the development process (including the usability test) of an AAT through the AT Openlab. Because the AAT outcome must be optimized according to the human activity and environment of the elderly and people with disabilities, the iterative process based on the interaction between the research (developer) and research participants (elderly or those with disability) should be considered.

This study presents a protocol for developing AAT using participatory-action research (PAR) including planning, developing, and testing AAT devices.

METHOD

1. Planning Stage

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Design

Literature review and expert advisory meetings on the usability test and development methodology were conducted. The existing usability test implemented a user-centered approach, created scenarios, collected data using an assessment tools, and conducted a focus-group interview.

Usability testing is a technique used in user-centered interaction design to evaluate a product by testing it on users. This can be considered as an irreplaceable usability practice, as it helps in determining how real users use the system. Usability testing is more focused on the design intuitiveness of the product and is tested with users who have no prior exposure to it(3). The International Standard Organization proposed the definition of usability and its elements by establishing ISO 9241-11 (Ergonomics of human-system interaction—Part 11: Usability: Definitions and concepts)(3). However, the appropriate methodology for developing AAT devices and testing of its usability were limited.

In a PAR, the cooperative relationship between the researcher and research participant affects the agile process and outcome of the research, the environment in which the research is being conducted changes, and the procedure is repeated in this iterative process, thereby influencing the experience and voices of the participant. This process can contribute to the continuity and processional development even after the implementation and to the discovery of behavior and development of the participant professionalism(4). If user opinions are not considered during the development of AAT, the development of the device deviates from the intention of the technology developer and from the application of PAR. The PAR is a product-development method in which the users directly participate and their opinions are considered to improve the understanding, accessibility, and familiarity of a new technology(5). Regarding the design in the present study, the process of discovery, definition, development, and delivery in the form of a double diamond is structured in a cyclic manner(6) using the PAR method. The process was conducted according to the methodology presented by an existing study(7). The current study was conducted based on the research ethics review by the National Rehabilitation Center (NRC-2020-043).

Measurement

To address the issues and achieve the necessary improvements by assessing the applicability of the assistive device and interacting with the environment and to effectively develop the device, we must investigate the following areas along with functional promotion(8). Thus, various assessment tools were used to identify the effects before and after the assistive-device application and to determine the effect on the surrounding environment that requires the application of assistive devices or to identify the functional level of the user. The International Classification of Functioning, Disability and Health, known more commonly as ICF, is a classification of health and health-related domains.The assessment tools were investigated according to the ICF classification based on preliminary considerations(9). The investigation included 23 body functions and structures, 36 activities and participation, and 17 environmental factors. Among these, the Policy, Human, Activity, Assistance, Technology, Environment (PHAATE), Individually Prioritized Problem Assessment (IPPA), World Health Organization Quality of Life–Brief (WHOQOL-Brief), Korean Version of Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0), and System Usability Scale (SUS) were commonly used. The PHAATE model was used for in-depth interviews with the users(10). To compare the conditions before and after the use of the AAT device, in addition to assessing the activity and environment of the user, the PHAATE model was used together with IPPA and WHOQOL-Brief. IPPA is an assessment tool that can be used to implement AAT devices, thereby comprehensively assessing the effectiveness of these devices that affect the daily life of users(11). WHOQOL-Brief is a tool developed by WHO to conceptualize and scientifically measure the quality of life(12).

The tools used for the usability test were QUEST 2.0 and SUS. QUEST 2.0 can identify the level of satisfaction of the user using the assistive device. It can also identify the satisfaction that follows functional improvement by assessing the satisfaction in using the AAT device. SUS can subjectively assess the effectiveness, efficiency, and satisfaction in terms of usability(13).

2. Implementation Stage

Six AAT devices were developed at AT Openlab in NRC in 2020 which is shown in Figure 2. Based on the first protocol through literature review and expert advisory meeting (Figure 2), a usability test was conducted with five subjects for using the backrest and safety belt in a bath chair, three subjects for using a rear camera, four subjects for using a holder, five subjects for using a K-lipsync, three subjects for nail clippers using feet, and one subject for putting socks on under the monitoring of an expert advisory group. The need for a scenario was additionally derived to assess the unified performance of the AAT device usability testing. The second protocol was completed by adding a post diary test for long-term follow-up on the usability, instead of a one-time use.

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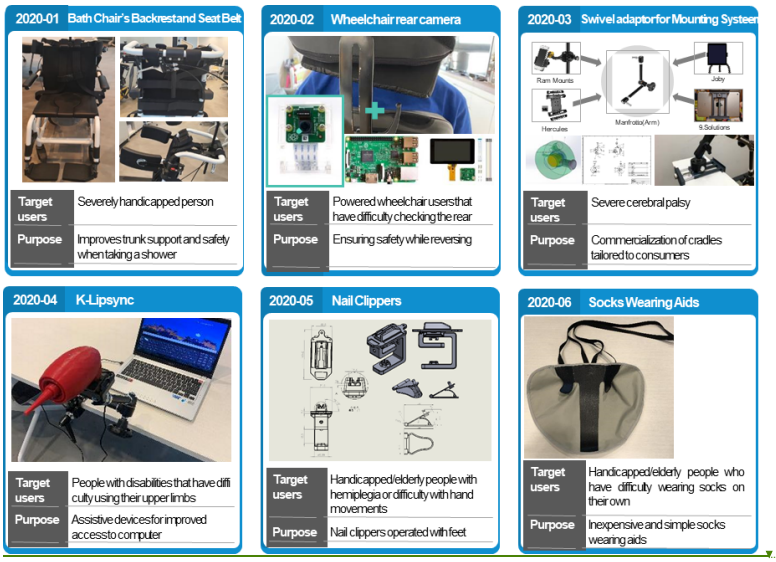

Figure 2. Development of Six AAT devices at the AT Openlab and usability

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3. Evaluation Stage

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The second modified protocol was presented in a multidisciplinary expert advisory meeting held with experts in occupational therapy, rehabilitation engineering, ergonomics, mechanical engineering, and computer engineering. The third (final) protocol was completed based on the modified second protocol.

RESULT

Procedure

Demand applications for AAT device was accepted through a website for participation of the elderly and those with disabilities. The AAT advisory group selected the subjects based on the inclusion criteria and prioritization (Stage 1). Among those selected, R&D planning and process for an AAT device were conducted for those who wish to participate in this study. In the preliminary assessment, we conducted an in-depth interview and pre-test (Stage 2). During the development process, a primary prototype was developed and applied in the usability test to the single subject. By correcting and supplementing the issues of the AAT device derived from the usability test, we developed a second prototype, conducted a usability test using few subjects (less than five subjects), and repeated the cyclic process (Stage 3). After the development was completed, we conducted the post-test, post in-depth interview, and post diary test (Stage 4). This process is schematically presented in Figure 3.

1. Selection of participants

The subjects of this study included the elderly and those with disabilities who resided in the local community or were hospitalized at the rehabilitation center, who wished to participate and were selected in the development and usability test of an AAT device. The exclusion criterion included those who did not consent to participate. The subjects were divided into single-scale and small-scale groups in the research process.

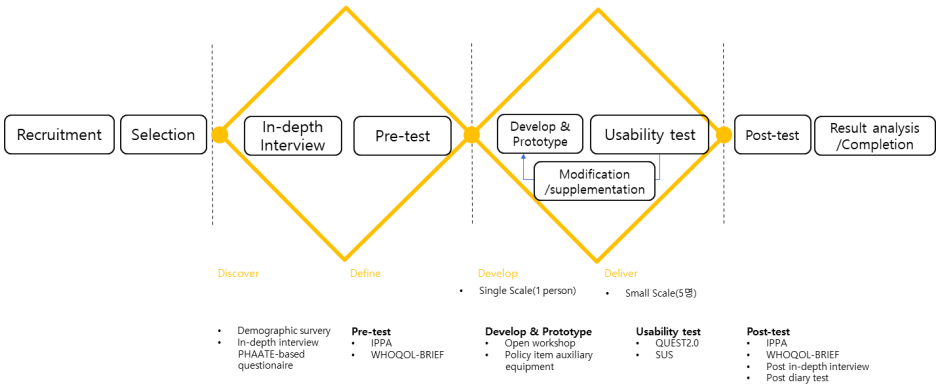

Figure 3. AAT development procedure at the AT Openlab in NRC, Korea

2. In-depth interview and Pre-test

The participants in this study underwent an in-depth interview to identify the physical functioning, activities, employed assistive devices, and user environment. The interview was `semi-structured based on the PHAATE model(14) shown in Figure 4. For the initial assessment, IPPA and WHOQOL-Brief were used(11, 12). To assess the functional level, activities, participation, and user environment or to identify the causes, we conducted the assessment using various assessment tools, such as the Reintegration to Normal Living Index, Geriatric Depression Scale and Assessment of Motor and Process Skills(15-17).

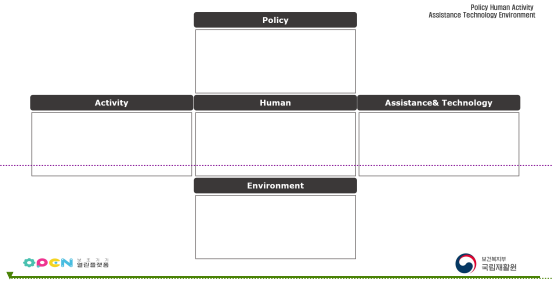

Figure 4. Semi-structured in-depth interview based on PHAATE

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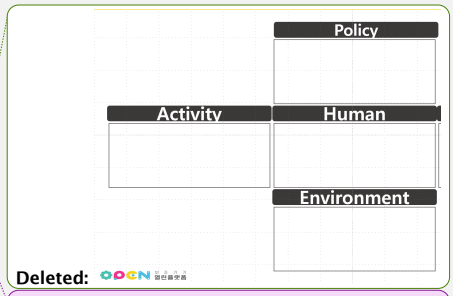

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3. Development, application, and usability test

We performed the usability test as a development process. The employed assessment tool included QUEST 2.0 and SUS(18, 19). We conducted the usability test while creating the first prototype in the single scale and corrected and supplemented it based on the results of the usability test, thereby creating the second prototype. We developed the assistive device by repeating this process for two to three times. The subjects were divided into single-scale and small-scale groups in the research process. The single-scale study developed an AAT device, and used it to conduct a usability test on one or two subjects. The cyclic process, which was aimed at deriving as many issues as possible from the AAT device and correcting and supplementing them, was repeated two or three times via the usability test. Through this process, the AAT device issues were identified to improve the device quality. Once a prototype was completed through this process, a usability test was conducted on the small-scale group of four to five subjects. Corrections and supplementations were made once or twice for issues found in the usability test with the small-scale group. Furthermore, the usability test was repeatedly measured once or twice in the small-scale group.

4. Post-test and post in-depth interview

The post-test was conducted after the completion of the development. The tools used here were IPPA and WHOQOL-Brief. In the post in-depth interview, feedback for the development process and opinions regarding the assistive devices that will be developed in the future were presented. The advantages and necessary improvements were assessed while using the developed assistive device through the post diary test.

DISCUSSION & CONCLUSION

This study was conducted using the PAR, double diamond, and various assistive technology assessment methods to provide the development protocol for AAT devices for the elderly and those with disabilities. The use of the PAR offers the possibility of developing an AAT device for a user by considering various feedback while maintaining the cooperative relationship with the users and solving issues from the user perspective. In addition, the makerspace provides a space with a universal design, which can be accessed by both the elderly and those with disabilities, allowing them to participate in the R&D process to develop AAT devices that are domestically available and made using affordable parts. In addition, this study allows the possibility of conducting a systematic development of AAT devices by applying a systematic research methodology. According to the protocol derived through this study, we can create a prototype that implements a minimum viable product by conducting a usability test in small scale (using five subjects) for an AAT device developed in a single scale (one subject). The prototype created in this manner can be made sufficiently robust to cross the Death of Valley of the AAT devices, which is the final step for commercialization, through usability test and verification in a large scale (using 30 subjects). We expect that the implementation of this research methodology will allow the development of systematic and efficient AAT devices(20, 21).

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