KnE Social Sciences | The 1st International Conference on Creative Design, Business and Society (1st ICCDBS) 2023 | KNE Publishing

Research Article

"I Don't Need Easy; I Just Need to Move": Evaluating Wheelchair Technologies for a More Inclusive World

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Abstract.
The wheelchair is an extreme representation of mobility through walking activities. Functionally, a wheelchair is an assistive device for people who cannot walk. However, from a "persona" perspective, a wheelchair is a part of the body that works differently from the way walking on two feet does. Both perspectives are valid, and their trains of thought are inseparable from the existence of technology. People with disabilities who cannot walk use technology to get to know the world. Conversely, the world is shaped through the experience of technology used by people who cannot walk. Wheelchairs are one of the technologies that change the construction of the world. The physical and social environment changes according to the needs of wheelchair users and the development of wheelchair technology. For example, battery technology and brushless DC motors are part of technologies that can be used to expand the displacement of a wheelchair, so that wheelchair users can expand their social interactions. The question is, which design is appropriate for technology to be used properly by wheelchair users? To answer this question, this article invites discussion about scenarios and designs that are appropriate for wheelchair users to weave into their environment. The approach is phenomenological, looking especially at the experience of wheelchair users who get to know and shape the world through technology. Experience mining, adapted from experimental design, within depth interviews, talk-aloud protocols, observations, and confirmations produce comparisons of experiences using appropriate technologies. The result of this research is a prototype which can be developed to help wheelchair users expand their micromobility or urban mobility.

Keywords: appropriateness, disability, experimental design, wheelchair

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Published: 19 November 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the 1st ICCDBS Conference Committee.

1. Introduction

Firstly, the title used for this article was inspired by Bethany Hamilton, a pro-surfer and shark attack survivor. "I do not need easy; I just need possible" is a quote from Bethany Hamilton which was then adapted to describe the struggle of wheelchair users in all daily activities. Determination, perseverance, and overcoming obstacles have become symbols of the struggle to uphold disability rights.

Second, mobility and accessibility are the main parts of the Convention on the Rights of Persons with Disabilities (CRPD) which has been ratified by the Indonesian government in the Republic of Indonesia Law No. 19 of 2011. Wheelchair users are one of the persons with disabilities who do not get their rights properly. Wheelchair users are an extreme condition of people moving by walking who need accessibility (Figure 1). Wheelchairs are a category of ways to move, like walking or running in a wheeling way besides using two feet.

Figure 1: Displacement extremity by walking. **Source:** Research documentation, 2022.

Third, disability rights in Indonesia especially Yogyakarta Special Region have not been implemented properly yet, even though the Republic of Indonesia Law No. 19 of 2011 and Regional Regulation No. 5 of 2022 have been affirmed. Policymaking for city development and arrangement does not fundamentally provide space for wheelchair users. This can be seen in the absence of pedestrian paths or slow lanes that can be accessed by wheelchair users (Figure 2). The presence of wheelchairs on the road, which is also a motor vehicle access, has its own consequences, both for wheelchair users and other vehicle users. However, in overcoming these problems, it is still more important to provide wheelchair features for speed rather than policy-makers indifference.

Fourth, the situation of wheelchairs that do not have a place on pedestrian paths or slow lanes requires wheelchairs to be on the road. Speed becomes a problem when wheelchairs are on the road. Therefore, wheelchairs need support to be able to increase

Figure 2: Wheelchair walked on the road. Source: Research documentation, 2022.

speed. At this stage, wheelchairs must be readjusted with technology so that they can integrate with their ecosystem.

2. Literature Review

2.1. Theoretical Framework

The construction of understanding in this article is based on four principles, (1) disability rights through CRPD which focus on mobility and accessibility, (2) contextual design that initiates solving real and everyday problems, (3) appropriate technology based on the application of technology that can be done locally, and (4) micro mobility that talks about the movement of people or goods by considering the size of the means of movement and ease of operation. The relationship between the four principles can be seen in the diagram below (Figure 3):

2.2. Disability Rights -- CRPD

The Convention on the Rights of Persons with Disabilities has been ratified by the Indonesian government through Constitution number 19 of 2011. Regarding the ratification, this article would like to highlight the accessibility and mobility listed in articles 9 and 20. Accessibility in the ratification states that the availability of accessibility by all parties (i.e., State, Private and Community) is intended so that people with disabilities are able to live independently and participate fully in all aspects of life. Accessibility

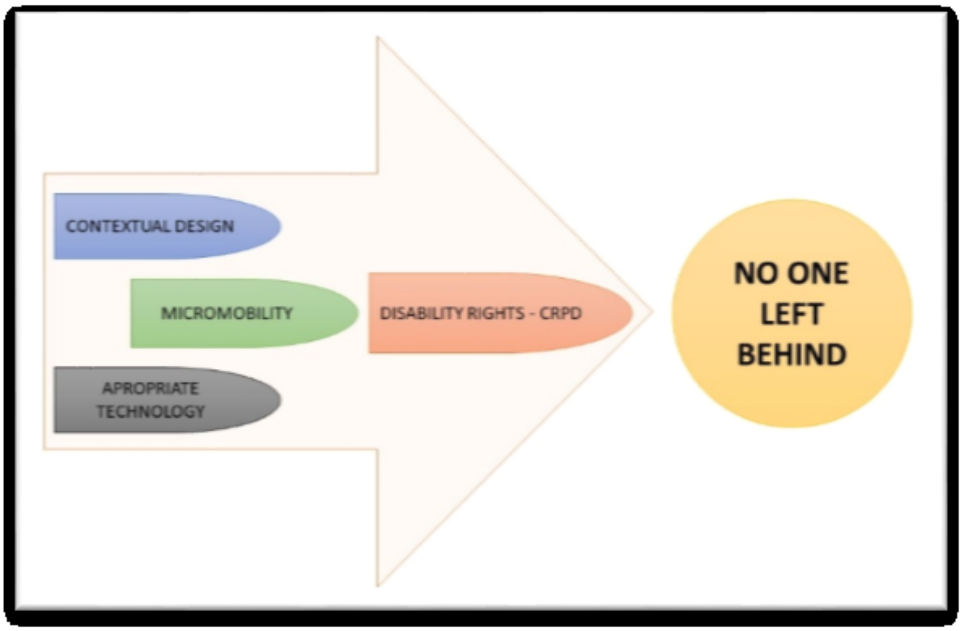

Figure 3: Framework. Source: Research documentation, 2022.

in this case can include physical access (e.g., buildings, roads, work facilities, media, public spaces) and non-physical (e.g., translators, guides, signs, applications, information systems, internet). While mobility is a form of facilitation (e.g., assistive tools, capacity building to build an ecosystem for the provision of assistive tools) that supports people with disabilities to move and displacements from one place to another.

Mobility in general can be interpreted as one aspect of everyone's rights and independence, including people with disabilities. Moving from one place to another, from personal space to public space, from home to the workplace, and producing social spaces are some of the forms of mobility [1(p3-10)-4]. In addition to relational moments in movement, people with disabilities also train themselves and improve their abilities and sensitivity by adapting to the surrounding environment [5(p1-15),6(p3-16)]. Positive social relationships will occur in everyone if people with disabilities can also play an active role to become a society [7,8].

2.3. Micro Mobility

Micro mobility is a concept that discusses the relationship between vehicle size, distance, speed, and energy consumption, which began in 2019. The definition of micro mobility states that its purpose is to offer maximum personal mobility with the smallest possible impact. Through the manifesto offered, micro mobility provides an important

note that transportation is a basic human right [9]. Micro mobility is classified as a vehicle with categories such as those in the table below (Table 1).

TABLE 1: Micro mobility Classification.

Type of Vehicle	Maximum Weight (kg)	Maximum Speed (km/jam)
Scooter	25	10
e-bike	50	19
Moped	100	34
Light quad	200	68
Heavy quad	500	97

Source: Zarif et al. [10]

It should be noted that the classification of micro mobility has not yet included motorized wheelchairs. However, in its application, many developments of electric wheelchair drive units that can be detached have emerged. The issue of micro mobility and battery technology development has also led to many innovations in wheelchair drive units [11-14].

2.4. Appropriate Technology

Friedrich Ernst Schumacher's thoughts on technology were divided into two perspectives: intermediate technology and appropriate technology. Intermediate technology focuses on simple technology that does not require higher education and is specifically designed to be operated, while appropriate technology focuses on adjusting the relationship between technology and the environment, social, traditions, culture, ethics, politics, and economics of the involved community [15,16].

Schumacher believed that technology used by large industries should be scaled down into simple technology that can be operated by the community. The availability of local resources such as humans and materials became very important for the sustainability of problem-solving through technology. At least the raw material and technological work are predominantly fulfilled and carried out by local resources.

2.5. Contextual Design

The contextual design concept in this article is based on Victor Papanek's thoughts that affirm the real problems of the world that must be solved by designers. Problem solvers

are the obligation of designers, therefore making products that meet the market is not enough. There are many real problems in everyday life that must be thought of to be solved, such as the carrying capacity for the elderly, disabled, and children, as well as the handling of waste that is always produced by humans [17].

Moral and social responsibility are principles that are strongly emphasized by Papanek in every design decision. A shift in production of beauty is not enough. Design must be able to be something meaningful by having use and impact in solving daily problems. Examples are the design of assistive devices for the elderly and disabled, or the manufacture of children's play equipment on the playground using production waste materials [18].

3. Methodology Research

The presence of wheelchairs and their users is a phenomenon, not only because it fulfils disability rights, but also because of the technology used. Technology has become the enforcement of disability rights and will certainly impact how the world changes. Wheelchair users use technology to explore a wider world and shape it. The shift from using manual wheelchairs to motorized wheelchairs brings a different perspective. The suitability of the technology for users and the environment forms a strong ecosystem. Therefore, an investigative activity is carried out through experimentation (Figure. 4).

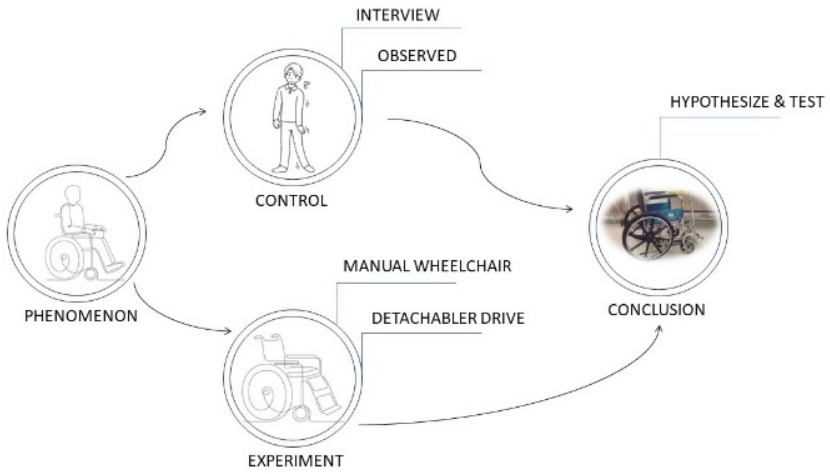

Figure 4: Flow of phenomenology-experimental design. Source: Research documentation, 2023.

To investigate how wheelchair users perform mobility through changes in wheelchair technology, a phenomenological approach is used. The approach is combined with

experimental design, which involves dividing the phenomenon into two parts: controlled phenomena and experimental phenomena. The activities involved in this approach are as follows:

1. The first step after obtaining the research framework is to find wheelchair-user participants without considering their background in using a wheelchair.
2. The second step is to conduct deep interviews with wheelchair users about their background in using a wheelchair and their experience of using a wheelchair.
3. The third step is to create a new mobility model that has never been used by wheelchair users.

The fourth step is to conduct a trial to generate a hypothesis for appropriate technological needs.

4. Results and Discussion

The research participants were ten partners in the ergonomic laboratory and inclusive design at UKDW. Interviews were conducted both in groups and individually. The location of the discussions and observations was chosen randomly but often took place at one of the participants' homes.

4.1. Wheelchair Experience

The research began with an investigation using depth interviews about the background of using wheelchairs, experiences using wheelchairs, and additional aids used for mobility using wheelchairs. This investigation found that the reasons for using wheelchairs are diverse. For example, paralysis and paraplegia caused by driving or work accidents. However, there are also those caused by diseases such as polio and degenerative problems.

Some of the problems that can be gathered through depth interviews related to the experience of using a wheelchair are:

1. The physical environment aspect: for example, differences in floor levels that do not provide ramps, or circulation spaces that make it difficult to steer a wheelchair, especially in toilets. In addition, access to public spaces is still a problem, such as pedestrian areas or slow lanes that are not accessible or even unavailable.

2. The mobility aspect: moving around the house can still be done by manually pushing the wheelchair. For travelling longer distances, wheelchair users use modified motorcycles with a sidecar. However, the problem arises when travelling further away from home or for short trips (e.g., under 30 minutes), such as going to a nearby store or a friend's house (e.g., 1-3 km). This is because it would be tiring to manually push the wheelchair for that distance, and if using a modified motorcycle, requires more preparation. The width of the modified motorcycle also becomes a problem when it has to enter narrow roads such as footpaths and village roads.
3. The social aspect: is the behaviour of the public that is still bound by ableism, such as the assumption that people with disabilities are unproductive, unable to learn, only a burden to others, and even still consider disabilities as something disgrace.

4.2. Detachable Drive Wheelchair

After obtaining the needs of wheelchair users, rapid ideation was carried out using sketches (Figure 5) to design the necessary aids for short-distance travel or micro-mobility. The development of ideas and sketching involved wheelchair-user participants.

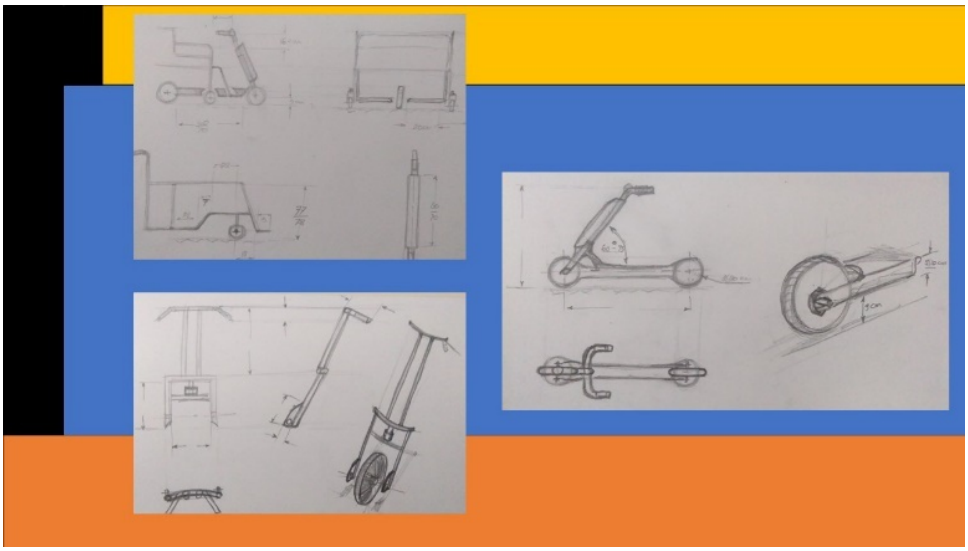

Figure 5: Sketch idea for detachable drive unit. Source: Guspara & Saputra [19].

The modelling of the idea development involved an engineering workshop in the city of Yogyakarta. This condition was intended to meet the needs of local technology and resources. There were several changes to the detachable model related to the type of wheelchair and installation method (Figure 6). The first design used a transfer wheelchair commonly used to transport patients in hospitals, while its development

used an adaptive wheelchair type used permanently by wheelchair users. The joint arm connection, adapter, and joint arm model also underwent several changes, from a single-arm model and a double-arm model.

Figure 6: Model of detachable drive unit. **Source:** Adhitia Guspara et al. [20].

The detachable drive is powered by electricity using a battery. Electric batteries were chosen because they are based on several factors, including ease of maintenance, clean energy use, ease of energy charging, and lower costs.

4.3. Fit Testing

The testing of the detachable model's compatibility was divided into two stages with two user characteristics. Before being used by wheelchair-user participants, compatibility was first tested by volunteers. The compatibility test includes human factors, mechanical function, electrical and instrument function, handling, and maneuverability.

The testing of compatibility by wheelchair user participants was conducted in two stages. The first stage was an introduction and familiarization with driving the detachable electric drive. The second stage involved testing the handling and manoeuvrability on roads (Figure 7). There are several improvements in the detachable component of the fit testing results (Table 2) obtained and then continued with the usability test.

Figure 7: Fit testing detachable drive unit. **Source:** Research documentation, 2023.

TABLE 2: Result of fit testing.

Items of fit testing	Status (+/-)	Participants Acceptances
Lock and release	-	Need easier
Turn on / off system	+	Easy to operate
Distance between body and steering	+	The body needs to lean on the backrest of the wheelchair
Throttle speed	+	Safe and easy to operate
Handling	+	Easy to maneuver
Brake system	+	Safe, easy, and works fine
Charging system	-	Need easier
Additional feature	-	Indicator light, headlight, taillight, horn, and side mirror.

Source: Documentation research, 2023

5. Conclusion

This research aimed to explore how the appropriate technology fitted the needs and capabilities of wheelchair users in the micro mobility context. The correct understanding of accessibility and human rights led to the urgent strategy to accommodate wheelchair users to extend their miles of mobility independently. The exploration of users' needs found three main aspects: physical (the environmental barriers), mobility (the need to access broader environment independently) and social (to show the competence to be at the same level as mainstream persons). The developed prototype gave an opportunity for wheelchair users to fulfil those three needs. The fit testing showed that

most of the assistive device items (i.e., lock and release, power switch, throttle speed, handling, brake system) have supported the safety and comfort of users. Additional features were needed to improve the safe riding and distance between steering system and the user could be better to ensure the ergonomic posture for wheelchair users. Overall, participants expressed their positive experience in using the detachable drive wheelchair. This prototype is appropriate to be tested further to explore this usability with more participants in different motorbike-riding experience.

Authors' Contributions

The authors confirm contribution to the paper as follows: study conception and design: WAG, LKPS; project supervision: YL; participants recruitment: WTS; Proto model: WAG, LKPS; data collection: WAG, WTS; experimental data processing: YL; IoT and application development: LKPS; analysis and interpretation: WAG, WTS; literature review: WAG, WTS; writer: WAG, WTS, LKPS, YL; critical review: WAG, WTS.

Acknowledgements

This project was supported by the Indonesian Directorate of Research, Technology Development and Community Empowerment [grant number 0254.6/LL5-INT/AL.04/2023]. This grant was under the contract agreement of The Higher Education Service Institutes (Regional 5) and Duta Wacana Christian University in 2023 in the research scheme: Superior Applied Research of Higher Education (Indonesian: Penelitian Terapan Unggulan Perguruan Tinggi). It was also collaborated by United Cerebral Palsy (UCP) Wheels for Humanity Indonesia.

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