Spektrum Industri
Vol. 24, No. 1, 2026, pp. 31-49
ISSN 1693-6590
https://journal3.uad.ac.id/index.php/spektrum/index

Designing Accessible Election Voting Booths: An Integrated Approach Using Universal Design, Design Thinking, and Ergonomics

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ARTICLE INFO

Article history
Received January 28, 2026
Revised April 3, 2026
Accepted April 16, 2026

Keywords
Accessible;
Design Thinking;
Election Voting Booth;
Ergonomic;
Universal Design.

ABSTRACT

Voting booths are one of the mandatory facilities for holding elections. However, currently, voting booths still face access barriers for people with disabilities who use wheelchairs. There is no standardization of voting booths that are easily accessible for all users and this is an urgent need for voting booth designs that are easily accessible for all users. Therefore, this study aims to design accessible voting booths for all users of voting rights. The method used in this study combines universal design approaches, design thinking, and ergonomics. Data collected included anthropometric data for people with disabilities who use wheelchairs, user need data for universal design-based voting booth designs, and user experience interview data for the empathy stage in design thinking. Data analysis used normality tests, uniformity tests, and adequacy tests for anthropometric data. On user need data, descriptive tests, level categorization and qualitative interpretation were conducted. Then, design thinking stages were carried out until design evaluation. The results of the study obtained an accessible voting booth design with dimensions of 70 cm leg room height; 75.5 cm lower table layer height; 93.2 cm upper table layer height; 92.9 table length; 55 cm table width and 55 cm booth cover height. The contribution of the study is expected to be an accessible voting booth design based on universal design, design thinking and ergonomics to become a technical guideline for the Indonesian general election commission to accommodate voter rights without discrimination.

1. Introduction

Elections are a fundamental instrument of democracy that guarantee the right of every citizen to participate in political decision-making. However, electoral accessibility for people with disabilities remains an unresolved structural issue in many countries, including those with established democracies. Americans with disabilities do not exercise their right to vote, with estimates indicating a potential loss of approximately 2.35 million votes in the 2018 federal election alone due to low voter turnout. This situation is inextricably linked to various systemic barriers encountered on the ground, ranging from the physical inaccessibility of voting booths, the lack of accessible ramps and parking, to ballot designs that do not accommodate the needs of voters with print or cognitive disabilities (Ihaab et al., 2022). The European Union itself still faces a gap between legal commitments and realities on the ground. Although the Convention on the Rights of Persons with Disabilities (CRPD) has been widely ratified, systemic barriers such as inaccessibility to polling stations, lack of appropriate information, the removal of legal capacity, and other disability-based discrimination persist (Rabitsch et al., 2023). While approximately 85% of African countries have ratified the UN Convention on the Rights of Persons with Disabilities (UNCRPD) and incorporated the principle of equality into their domestic legislation, implementation on the ground still shows a wide gap between legal commitments and practical realities. Political participation of persons with disabilities in the region remains hampered by three main factors: a lack of educational and financial resources that limit political awareness and the ability to run for office; cultural stigma and negative social attitudes that tend to underestimate their leadership capacity; and inaccessible physical infrastructure at voter registration and polling stations (Virendrakumar et al., 2018).

Indonesia upholds democratic values in its governance system, enabling its citizens, including people with disabilities, to actively participate in political and governmental affairs. One manifestation of this democratic practice is the General Election (PEMILU), which serves as a medium for the public to express their political aspirations by electing their leaders (Astuti & Suharto, 2021). Elections give all citizens the right to elect government representatives and influence policy direction (Kirom, 2015). The election process is managed by the General Elections Commission (KPU), the Election Supervisory Agency (BAWASLU), and the Election Organizer Honorary Council (DKPP). At the field level, election implementation and voter services are handled by temporary bodies such as the District Election Committee (PPK), the Voting Committee (PPS), and the Voting Organizer Group (KPPS) (Ginting et al., 2021).

Article 13 of Law Number 8 of 2016 affirms the political rights of persons with disabilities, including the right to vote and be elected to public office, express their political views both verbally and in writing, vote for political parties or candidates in general elections, establish or join organizations specifically representing persons with disabilities and represent their interests at the local, national, and international (Bitonti, 2022; Ghosh, 2022). This law also guarantees their full participation in all stages of the election process, access to election-related facilities and infrastructure, and the right to obtain political education.

According to KPU data, there are 1,101,178 voters with disabilities registered on the Permanent Voter List (DPT) for the 2024 Election, representing 0.54 percent of the total 204.8 million national voters (Stephanus, 2024). This number is significantly lower than the estimated 37,414,960 people with disabilities projected from the 2020 BPS Population Census (SPT). In Kudus Regency, local KPUD data shows 2,786 people with disabilities registered on the 2024 Election DPT across nine sub-districts. Although the percentage of voters with disabilities in the DPT is relatively small, ensuring equal voting rights and the right to vote is very important, including the provision of adequate and accessible facilities and infrastructure.

Accessibility encompasses the extent to which all individuals can use environments and facilities without barriers and discrimination (Groulx et al., 2022), including providing facilities for users with special needs to ensure equal rights in social and spiritual life (Rangga et al., 2020). Accessibility is also crucial for people with disabilities to live independently and fully and equally participate in society. Without adequate access to the physical environment, transportation, information and communication, and other public services, people with disabilities will lose equal opportunities for active participation (ESCAP, 2019). This concept was originally introduced by Hansen in the 1950s in the field of transportation planning and has evolved over time, driven by advances in technology and computing capabilities that facilitate more complex analyses (Ravensbergen et al., 2022). Accessibility of polling stations (TPS), particularly the design of voting booths, often faces challenges in the implementation of general elections as a manifestation of people's sovereignty. In general, there are discrepancies in the physical standards of voting booths and the impact on vulnerable voters. The standard voting booth design used by the KPU is rectangular with static heights and dimensions, often not considering the principle of universal access (Syarif et al., 2019). Referring to center civic design, there are layout designs for voting booths (Sokhibi et al., 2020) including the design of voting booths (Wijk et al., 2025).

Initial interviews with the Kudus Disability Communication Forum (FKDK) revealed that accessibility issues for people with disabilities are often overlooked in public events such as elections. For example, voting booths at polling stations (TPS) often use random tables without standard heights, thus neglecting the accessibility and comfort needs of wheelchair users. As a result, people with disabilities who use wheelchairs face difficulties when voting because their wheelchairs cannot fit under the tables.

Efforts to overcome accessibility barriers in voting booths during vote collection require a systematic approach, particularly through the principles of universal design, design thinking, and ergonomics, which directly direct design solutions to meet the accessibility, comfort, and functional needs of all voters. Universal design is a human-centered approach to creating products and environments that can be used by everyone, without the need for adaptation. The goal is to reduce accessibility barriers to environments or products for all individuals, including those with disabilities (Watchorn et al., 2023). The concept of universal design was initiated by Ronald L. Mace, Director of the Center for Universal Design at North Carolina State University, in 1988 (Tutal, 2018). It then evolved by introducing seven universal design principles recognized by the WHO in 1997. The seven principles are: Fair use, Flexibility in use, Simple and intuitive use, Clear information, Tolerance for errors, Low physical effort, and Size and space for approach and use (Santana et al., 2021). Universal Design (UD) principles not only support accessibility for people with disabilities but also offer benefits that can benefit the general public (Marisa, 2020). Meanwhile, design thinking is a problem-solving approach that focuses on empathy, collaboration, and creativity to generate innovative solutions. This method is universal and can be applied in various fields by anyone, regardless of educational background or profession (Chung et al., 2016). Meanwhile, ergonomics can be applied to reduce potential inequalities by integrating physical fit and social accessibility, and highlighting how ergonomic design can encourage the accumulation of social capital that supports the physical and social well-being of its users (Celik et al., 2025).

Several studies have highlighted the importance of implementing and extensively exploring the effectiveness of Design Thinking and Universal Design approaches in various contexts, ranging from innovations in teaching policies in the form of learning facilities (Nguyen et.al, 2022) to analysis of physical and virtual environments (Minet et al., 2024). In the realm of product design and ergonomics, the application of Universal Design has been shown to improve the aesthetics and functionality of furniture (Inoue & Nakajima, 2021; Rinaldi et al., 2025), as well as accommodate variations in user physical loads through digital human modeling (Inoue & Nakajima, 2021), where a literature review also emphasizes the importance of comprehensive ergonomic assessment methods (Bai et al., 2024). Furthermore, ethical aspects and accessibility standards in Universal Design have been identified as crucial elements to ensure inclusivity in the workplace and public open spaces (Gupta et al., 2025). However, despite advances in furniture and public space design, the implementation of these inclusive principles still faces significant barriers in political infrastructure. Case studies in the European Union and analysis of the 2024 Jakarta election revealed that voting booth facilities often fail to meet accessibility standards for people with physical disabilities, both due to excessively high and unstable table dimensions and a regulatory focus that is heavier on physical material aspects than on functional accessibility (Alemande et al., 2024; Rabitsch et al., 2023).

While existing literature has provided a deep understanding of the urgency of political accessibility and the application of inclusive design, a significant research gap remains in the context of election infrastructure. To date, previous research has tended to focus on evaluating legal barriers, descriptive post-election physical assessments, and digital election design (Harits et al., 2025). However, it has not comprehensively integrated Design Thinking methods, Universal Design principles, and ergonomic approaches into the process of developing accessible voting booths for voters with disabilities. No studies have been found that explicitly synergize user comfort analysis through ergonomic modeling with the iterative process of human-centered design to create functional voting booths. Therefore, there is an urgent need for research that goes beyond purely physical material standards, exploring how the integration of these three design approaches can produce political infrastructure solutions that not only comply with regulations but also ensure the independence, dignity, and ergonomic comfort of the entire spectrum of voters within the voting booth (Hindayanti et al., 2024).

Based on this gap, this study aims to design a voting booth model for wheelchair users by integrating Universal Design and Design Thinking methods, providing concrete solutions to election accessibility issues that have not been addressed in previous studies. The novelty of this study was the design of an accessible modular voting booth with adjustable height and geometry that is comfortable for both disabled and wheelchair users without drastically changing the booth's physical shape. The primary contribution of this study was that this design contributes to ensuring the right to equal access to voting, a frequently overlooked right. Furthermore, this study also provides policy recommendations for the KPU in the form of guidelines for technical specifications for voting booth designs that meet Universal Design standards in order to achieve inclusive and equal elections.

2. Method

This study used quantitative and qualitative methods with a universal design, design thinking, and ergonomic approach. The data collected include anthropometric data of wheelchair users, user needs data of universal design implementation. The focus of this study is the design of a voting booth model that is accessible to wheelchair users. Wheelchair users act as study participants. The tools used in this study include questionnaires, anthropometers, and Inventor software. Literature Review and Field Study, the literature review used in this study consisted of scientific articles published in scientific journals and international proceedings (Sokhibi et al., 2022). Field studies, including direct observation, documentation from sermon pulpits, and interviews with pastors, served as the initial steps in this study. Problem identification, problem identification was conducted based on the issues identified in the field study. Research objectives determination, the research objectives were established to answer the research questions (Putri et al., 2024). The data collected includes first anthropometric data of disabled people using wheelchairs from the Kudus Disability Communication Forum (FKDK) Central Java and non-disabled voters with Respondent characteristics are 15 disabled people using wheelchairs and 10 normal people or non-disabled, aged at least 17 years and have an identity card, male or female, have the right to vote and have experience at polling stations. Anthropometric Measurement Procedures.

Subject Preparation and Environment: Subjects are measured standing upright, barefoot on a flat floor, and wearing light clothing. Measurements are taken in the morning to avoid spinal compression due to daily activities. For wheelchair users, the chair is locked in its standard operating position. (2) Tools Used: Anthropometer and Measuring Tape (Metlin). (3) Dimensional Measurement: The dimensions measured are elbow height when sitting, arm reach, shoulder width, and knee height when sitting. (4) Measurement standards are based on anthropometry textbooks (Hari, 2013). Second, user needs data for universal design-based polling station design was collected through a Likert scale questionnaire with numeric categories 1–5, where 1 means strongly agree, 2 means agree, 3 means neutral, 4 means disagree, and 5 means strongly disagree. Respondents who filled out the questionnaire were wheelchair users from the Kudus Disability Communication Forum (FKDK) Central Java with characteristics of male and female respondents, a minimum age of 17 years, and respondents had experience voting at polling stations. Third, user experience interview data for the empathy stage in design thinking. As seen in Eq. (1), Eq. (2), and Eq. (3), the first stage of data processing involves analyzing anthropometric data using normality, uniformity, and adequacy tests to obtain percentile values that will be used as design measurement values. The formula for obtaining percentile values were (Robert, 2017).

$$P_5 = \bar{x} - S.\,Z \quad (1)$$

$P_{50} = \bar{x}$ ……………………………………………………………………………………..(2)

$P_{95} = \bar{x} + S.Z$……………………………………………………………………..…..... (3)

The second stage of data user needs was quantitative descriptive statistics. The average value of the data obtained from the Likert-scale questionnaire was calculated to determine the tendency of respondents' perceptions regarding voting booth accessibility. The results were then analyzed qualitatively by comparing the scores against the 7 Universal Design Principles to identify user needs. There are three stages: (1) mapping ergonomic approaches to voting booth design, (2) the mapping stage of 7 universal design principles, and (3) the design thinking stage (identifying user needs, defining/formulating the problem, brainstorming and focus group discussions (FGD) (co-design). The design is then visualized in the form of an engineering design and a 3D model. This stage involves qualitative testing of the design with user experts (people with disabilities using wheelchairs). The discussion presents research findings and comparative references related to the research findings. The conclusion contains key points that answer the research objectives.

3. Results and Discussion

3.1. Anthropometric Data

The anthropometric data used in designing this voting booth included sitting elbow height, arm reach, shoulder width, arm reach, and sitting knee height. Table 1 below shows the results of the anthropometric data measurements.

Table 1. The anthropometric data

Sitting Elbow Height (cm)	Forward Grip Reach (cm)	Shoulder Breadth (cm)	Vertical Grip Reach (cm)	Knee Height (cm)
25.5	39.0	45.0	135.0	50.0
24.8	41.5	43.5	142.5	48.5
26.1	40.0	46.2	138.0	51.2
25.0	38.5	44.0	131.0	49.5
27.0	42.1	47.5	145.5	52.0
25.3	39.8	44.8	133.5	49.0
26.5	43.0	46.8	140.0	50.5
24.5	37.5	43.0	130.5	47.0
25.9	40.5	45.5	143.0	51.0
27.2	41.0	48.0	148.0	53.0
25.6	39.2	45.2	136.5	49.2
24.9	41.8	43.8	132.0	48.8
26.2	40.2	46.4	139.5	51.4
25.1	38.7	44.2	141.0	49.7
27.1	42.3	47.7	146.0	52.2
25.4	39.9	44.9	134.5	49.1
26.6	43.2	46.9	144.0	50.7
24.6	37.7	43.2	129.5	47.2
26.0	40.7	45.7	137.5	51.2
27.3	41.2	48.2	147.0	53.2
25.7	39.4	45.4	135.8	49.4
24.7	42.0	44.0	141.5	48.7
26.3	40.4	46.6	130.0	51.6
25.2	38.9	44.4	145.0	49.9
27.4	42.5	47.9	138.5	52.4

Table 1 shows the range of values among subjects that demonstrate natural human variation. For example, sitting elbow height ranged from 24.5 to 27.4 cm; forward grip reach ranged from 37.5 to 43.2 cm and vertical grip reach varied significantly from 129.5 to 148.0 cm.

3.2. User Need Data

User needs data was obtained by distributing a Likert-scale questionnaire to 24 wheelchair users with disabilities online. The user needs data criteria were used to determine the accessibility aspects of the current voting booth using a universal design approach. A summary of respondents' responses can be seen in Table 2 below.

Table 2. User Need Data Result

Respondents	Q1	Q2	Q3	Q4	Q5	Q6	Q7
1	2	2	4	3	2	1	1
2	1	2	3	3	2	2	1
3	2	3	5	4	3	2	2
4	1	1	4	2	1	1	1
5	3	2	4	3	2	2	1
6	2	2	4	3	3	1	2
7	2	2	3	2	2	2	1
8	1	3	4	4	2	1	1
9	2	2	4	3	3	2	2
10	2	2	4	3	2	2	1
11	2	2	3	2	2	1	2
12	1	1	4	3	2	2	1
13	2	2	4	4	3	1	2
14	2	3	4	3	2	2	1
15	2	2	4	2	2	2	2
16	2	2	4	3	3	1	1
17	1	2	4	4	2	1	1
18	2	2	4	3	2	2	2
19	2	2	4	2	3	2	1
20	2	3	4	3	2	1	1
21	1	2	4	3	2	2	2
22	2	2	4	4	2	2	2
23	2	2	3	3	2	1	1
24	2	2	4	3	2	2	2
Average	1.79	2.08	3.88	3	2.21	1.58	1.42
Total	43	50	93	72	53	38	34

Table 2 shows the current voting booth design is deemed to fall short of Universal Design principles, with the most critical weaknesses being in the physical and ergonomic aspects. The majority of respondents gave very poor ratings for the Size and Space (Q7) aspect with the lowest average of 1.42 and Physical Effort (Q6) at 1.58, indicating that the lack of knee clearance and tables that are too high are the main barriers to accessibility. These physical dimensional constraints lead to a low sense of equality (Q1) with a score of 1.79, but on the other hand, the cognitive aspect is considered good, with respondents feeling the layout of the voting equipment is Simple and Intuitive (Q3) with the highest score of 3.88. Therefore, the urgency of redesign must prioritize improving the structure and dimensions of the table to accommodate the ergonomics of the sitting position, without the need to change the voting mechanism or layout that users are already familiar with.

3.3. Data Analysis

Data analysis of anthropometric was carried out using three data tests, data normality test, uniformity test, and data sufficiency test. This test aims to determine the normality of the anthropometric data, the uniformity of the anthropometric data, and the sufficiency of the anthropometric data. Normality Test conducted using the Kolmogorov-Smirnov test in SPSS software. Data is said to be normally distributed if the predetermined significance value (alpha), which is 0.05, is greater than alpha ($p > 0.05$), then the decision taken is to accept the null hypothesis (H0), which states that the data is normally distributed. Table 3 and Table 4, shows the results of the normality test for anthropometric data.

Table 3. Normality Test Result

Anthropometric Data	Asymp. Sig. (2-tailed)	Significance Level (α)	Decision
Sitting Elbow Height	0.200	0.05	Normal
Forward Grip Reach	0.200	0.05	Normal
Shoulder Breadth	0.200	0.05	Normal
Vertical Grip Reach	0.200	0.05	Normal
Knee Height	0.200	0.05	Normal

Anthropometric data uniformity test was conducted using SPSS software. This will determine the upper and lower control limits. Data are considered uniform if they fall within the Upper Control Limits (UCL) and Lower Control Limits (LCL).

Table 4. Uniformity Test Result

Anthropometric Data	$\overline{X}$	SD	Upper Control Limit	Lower Control Limit	Decision (α=0.05)
Sitting Elbow Height	36.77	3.070	27.40	24.50	Uniform
Forward Grip Reach	43.80	4.334	43.20	37.50	Uniform
Shoulder Breadth	44.60	3.286	48.20	43.00	Uniform
Vertical Grip Reach	58.23	6.500	148.00	129.50	Uniform
Knee Height	63.77	2.161	53.20	47.00	Uniform

The comparison graph of the UCL and LCL of Anthropometric Data can be seen in Fig. 1.

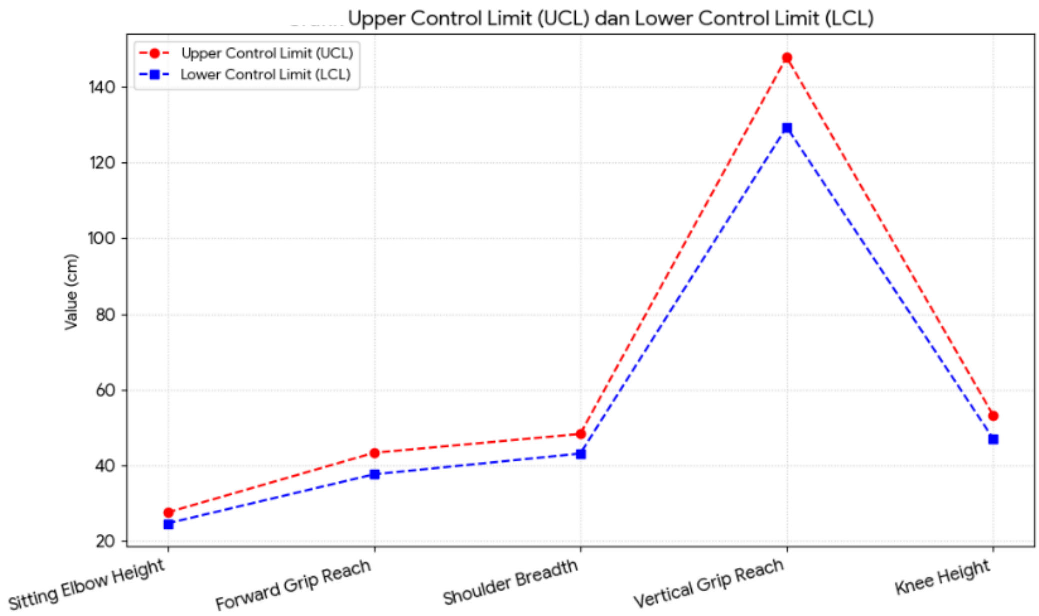

Fig 1. Upper control limit and lower control limit chart

The data sufficiency is conducted to determine whether the data used is sufficient or not, namely N' < N. Using a 95% confidence level and a 5% accuracy level. The Eq. (4), used to find the value of N' is as follows (Iftikar, 2006):

$$N' = \left[\frac{\frac{k}{s}\sqrt{N(\sum_{j=1}^{n} x_j^2) - (\sum_{j=1}^{n} x_j)^2}}{(\sum_{j=1}^{n} x_j)} \right]^2 \tag{4}$$

The results of the anthropometric data sufficiency test can be seen in Table 5 below.

Table 5. Sufficiency test result

Anthropometric Data	N	N′	Comparison (N′ vs N)	Decision
Sitting Elbow Height	25	1	1 ≤ 25	Sufficient
Forward Grip Reach	25	2	2 ≤ 25	Sufficient
Shoulder Breadth	25	1	1 ≤ 25	Sufficient
Vertical Grip Reach	25	3	3 ≤ 25	Sufficient
Knee Height	25	3	3 ≤ 25	Sufficient

Percentile calculation used to represent the population of an ergonomic design user group. The percentile measures used are the 5th to represent the small percentile population, the 50th to represent the average percentile population, and the 95th to represent the large percentile population To calculate the percentile value, an equation is used that refers to (Bridger, 2017). Table 6 shows the percentile values.

Table 6. Percentile calculation result

Anthropometric Data	$\overline{X}$	σ	P5 (cm)	P50 (cm)	P95 (cm)
Sitting Elbow Height	25.84	0.91	25.53	25.84	26,15
Forward Grip Reach	40.44	1.61	37.80	40.44	43,09
Shoulder Breadth	45.55	1.60	42.92	45.55	48,18
Vertical Grip Reach	138.61	5.69	129.25	138.61	147,97
Knee Height	50.26	1.67	47.51	50.26	53,01

The questionnaire data using a 5-point Likert Scale was quantified by giving a weighting value of 1 to 5. The data was then processed using descriptive statistics in the form of an average value (Mean) to determine the tendency of respondents' perceptions (Central Tendency) towards each design variable. Table 7 shows the descriptive test.

Table 7. Descriptive test result

Variables	N	Min	Max	Sum	Mean	SD
Q1	24	1.00	3.00	43.00	1.7917	.50898
Q2	24	1.00	3.00	50.00	2.0833	.50361
Q3	24	3.00	5.00	93.00	3.8750	.44843
Q4	24	2.00	4.00	72.00	3.0000	.65938
Q5	24	1.00	3.00	53.00	2.2083	.50898
Q6	24	1.00	2.00	38.00	1.5833	.50361
Q7	24	1.00	2.00	34.00	1.4167	.50361

Based on the results of descriptive statistical analysis of 24 respondents revealed a polarization between physical failures and cognitive successes: Size/Space (Q7) and Physical Effort (Q6) were rated as ergonomically very poor, while Simple/Intuitive (Q3) received the highest score. The consistency of respondents' responses (low standard deviation) confirms that the redesign priority should focus on improving the physical dimensions of the booth without altering the already effective voting mechanism.

Furthermore, a Qualitative Interpretation Analysis is also carried out on user data needs. The level categorization was determined using the class interval formula: (Maximum Score - Minimum Score): Number of Classes = (5 - 1): 5 = 0.8. levels 1.00 – 1.80: Very Poor (High Priority for Improvement); 1.81 – 2.60: Poor (Needs Improvement); 2.61 – 3.40: Fair (Neutral); 3.41 – 4.20: Good (Maintainable); 4.21 – 5.00: Very Good. The following Table 8 shows this analysis.

Table 8. Qualitative interpretation analysis

Universal Design Principles	Mean	Category	Problem Analysis & Interpretation
Equitable Use	1.79	Very poor	Respondents felt discriminated against because the current design required them to seek assistance from others, reducing their independence and privacy
Flexibility in Use	2.08	poor	The voting booths were rigid and static. They did not accommodate left-handed users or wheelchair users who had to sit at an angle due to space constraints
Simple & Intuitive	3.88	Good	(Strength) Respondents understand how to vote. The layout of the nails and ballots is logical and easy to understand.
Perceptible Information	3.00	Neutral	Lighting and visual cues were within standard limits. However, shadows from seated individuals sometimes obscured the voting area
Tolerance for Error	2.21	Poor	The construction was deemed insufficiently sturdy. Respondents were concerned that the booth would shift or collapse if it were to be hit by a wheelchair footrest.
Low Physical Effort	1.58	Very poor	(Critical Issue) High fatigue levels. The desk position is too high, forcing the shoulders to lift and the arms to reach excessively
Size & Space for Approach	1.42	Very poor	(Main Problem) No knee clearance. The wheelchair legs hit the table wall, forcing the body to bend over

Table 8 shows that the voting booth design shows a significant gap between cognitive ease of understanding and physical accessibility. Cognitively, the design is considered successful, with the Simple & Intuitive (Q3) aspect receiving the highest score (3.88/Good), indicating that users understand the voting mechanism; however, ergonomically and physically, the design fails miserably. The greatest failures are seen in the "Very Poor" categories for Size & Accessibility (Q7) and Low Physical Effort (Q6) with the lowest scores (1.42 and 1.58), indicating that the lack of knee room and the high table position force wheelchair users to exert excessive effort and lose independence (Equality of Use/Q1), exacerbated by weak construction (Q5) and lack of flexibility (Q2). The Design Phase consists of three stages that are centered on human needs, namely the mapping stage of the 7 UD principles in design, the mapping stage of the ergonomic approach, and the design thinking stage.

This anthropometric data-based ergonomic mapping aims to translate the dimensional needs of the human body particularly regarding knee clearance and arm reach into precise design specifications, in order to minimize physical effort and ensure independence and equal access for the entire spectrum of voters, including wheelchair users. Table 9 shows the implementation of ergonomics in the design of the voting booth.

Table 9. Implementation of Ergonomic approach in voting booth design

Design Dimensions	Anthropometric Data	Percentile	Implementation
Knee Clearance Height	Knee Height + Thigh Thickness	95th Percentile	53.01 cm + 16.99 cm
Knee Clearance Depth	Forward Grip Reach	95th Percentile + Allowance	43.09 cm + Allowance 6.91 cm
Table Surface Height (two layers)	Elbow Height Sitting + Knee Height	5th Percentile	7.5 cm
	Standing Elbow Height + Knee Height		93.3 cm
Entry Width	Shoulder Breadth	95th Percentile + Allowance	48.18 + Allowance 44.72 cm
Visual Privacy Height	Vertical Grip Reach	95th Percentile	148.20 cm

This section presents a comprehensive mapping of existing voting booth designs, reviewed based on the seven principles of Universal Design, to objectively evaluate their accessibility and inclusivity. Table 10 shows the application of universal design principles in the design of the voting booth.

Table 10. Implementation of universal design principles in Voting Booth Design

Universal Design Principles	Application in voting booth Design
Equitable Use	Integrated Design: One booth model that can be used by both standing (non-disabled) and sitting (wheelchair/elderly) users. No need for separate "special booths"
	Equal Privacy: Visual barriers (booth walls) that are high enough to maintain the privacy of standing voters, but low enough not to isolate wheelchair users.
Flexibility in Use	Adjustable Table: Provides two table height levels in one unit
	Ambidextrous: The table area is spacious enough to comfortably access the voting nail with both the right and left hand.
Simple & Intuitive	Clean Layout: Tables free of distractions, ballot holders, nails
	Visual Instructions: Voting pictograms are posted on the front wall of the booth (at eye level), not long text.
Perceptible Information	High Contrast: The color of the table contrasts with the color of the ballot paper, so that the paper is easily visible for those with low vision
Tolerance for Error	Sturdy Construction: Table legs with weights or non-slip pads to prevent collapse if hit by a wheelchair footrest.
	Safety Edges: Table corners are rounded (fillet/chamfered) to prevent injury if the user is hit
Low Physical Effort	Ergonomic Reach: Ballots are placed within arm's reach (no need to bend far forward)
Size & Space for Approach	Knee Clearance (Critical): Provide a minimum of 70cm high and 50cm deep under the table to allow the wheelchair user's feet to fully fit.
	Cubicle Width: Minimum 80-90cm between posts to accommodate standard wheelchair widths.

The stage consists of Empathy (deep understanding of user experience), Definition Stage (defining the problem), Idea/concept Stage (generating various potential design solutions), and Prototype Stage. This phase focused on gaining a deeper understanding of the experiences, challenges, and specific needs of wheelchair users when participating in elections. The goal of this phase was to collect qualitative data and foster empathy for users. In-depth interviews were conducted with four disabled wheelchair users from the Yogyakarta Humanitarian Wheel Foundation via Zoom. Table 11 shows a summary of the interview results.

Table 11. Summary of Interview Results with Disabled Wheelchair Users

Questions	Participant A	Participant B	Participant C	Participant D
How frequently do you utilize this facility?	3 times	Once	5 times	Twice
What is your level of enthusiasm or motivation when visiting this facility?	Highly enthusiastic	Moderately enthusiastic	Neutral / Indifferent	Enthusiastic
Is the polling station entrance accessible?	Yes (Entrance path)	Yes (Queue area and long distance to station)	No (Only the voting booth)	Yes (All circulation areas)
Did you encounter any physical barriers or spatial constraints?	Yes (Narrow doorway, difficult to turn/maneuver)	Yes (Standard booth blocked by a table)	No (Assisted by officers)	Yes (Severely restricted movement space)
Did you experience any difficulties regarding the height or reach of the fixtures?	Yes (Too high, required excessive reaching)	Yes (Unable to view the ballot paper)	No (Participant stood up, did not sit)	Yes (Standard table, inaccessible)
How would you describe your emotional state and perceived effort during the usage?	Difficult and Anxious	Cramped / Constrained	Safe (Due to full assistance)	Frustrated
Did the facility fully meet your expectations	No	No	No (Standard booth issue)	No

Questions	Participant A	Participant B	Participant C	Participant D
regarding safety and comfort?				
Were you able to use the facility completely independently without assistance?	No (Required help due to reach difficulty)	No (Officer had to assist in punching the ballot)	Yes (Able to stand, not a full wheelchair user)	No (Had to ask officer to hold materials)
Did you feel confident or secure regarding your privacy while inside the cubicle?	Hesitant (Assisted inside the booth)	No (Others could see from above)	Yes	Hesitant (Had to open curtain for officer)
To what extent does the facility design influence your willingness to use it?	Significantly influences	Yes (Creates dependency)	Insignificant influence	Significantly influences
What specific design improvements or features do you recommend?	Adjustable table height, Wider room clearance	Turning space (150 cm radius), Adequate lighting	Separated voting area with easy access	Knee-height table, Mirror to view lower area
What is your primary priority when using the facility, and what trade-offs are you willing to make?	Priority: Independence Trade-off: Comfort	Priority: Accessibility Trade-off: Privacy (if necessary)	Priority: Confidentiality Trade-off: None	Priority: Independence Trade-off: Confidentiality

Table 11 above shows that the main challenges for wheelchair users during elections revolved around spatial dimensions (accessibility, maneuverability) and the height of the voting table. There was a strong correlation between poor design and loss of independence and confidentiality, as access difficulties force users to rely on assistance, compromising confidentiality. This is because the majority of participants prioritized independence. The main objective of this stage is to formulate a clear, user-centered, and actionable problem statement, also known as a Point-of-View (POV) Statement. Table 12 shows the POV results from the interviews.

Table 12. POV elements of interview results

POV Elements	Findings from Interviews
User	Wheelchair users participating in elections.
Need	Voting booths that allow for maneuverability and an appropriate table height (accessible)
Why	This allows them to exercise their right to vote independently, comfortably, and confidentially, which is currently compromised by standard booth designs

Wheelchair users participating in elections require voting booths designed with adequate turning space and adjustable table height (accessibility) because the current standard booth design severely restricts manoeuvrability, forcing them to seek assistance, ultimately compromising their independence and the confidentiality of their vote.

This phase was expected to generate as many creative solutions and ideas as possible to address the defined problem. The goal is to find innovative solutions that are superior to conventional/previous voting booth designs. This stage also involves benchmarking and lateral thinking, referring to global voting booth designs: accessible voting booths (ADA USA) in developed countries (the United States and Japan), and non-election solutions: ergonomic office furniture design.

Table 13. Design idea

How Might We (HMW) Focus	Idea Method	Example Ideas
Access & Maneuverability	Sketch	Inverted U-shaped chamber; Modular rooms that can be combined
Independence & Height	Changing Assumptions	The booth table uses a manual hydraulic crank system; the ballot board can be pulled/slid.
Dimension & Efficiency	Cross ideaa	A dual-purpose voting booth (having two levels of height); A portable booth whose frame can be folded flat and quickly assembled.

As seen in Table 13, once several voting booth design ideas were available, the next step was to refine these design ideas into several voting booth design concepts that best addressed user needs, addressing accessibility, comfort, and confidentiality. The refinement of design concepts can be seen in Table 14, Table 15, and Table 16.

Table 14. Prototype concept 1

Key Features	Design Description	Addressed Needs
Manual Crank Table	A voting table whose height can be manually adjusted (raised/lowered) using a simple crank on the side of the booth. The height range follows the standard seated reach (approximately 75 cm to 95 cm).	Addressing the issue of inaccessible table heights. Ensuring wheelchair users can vote without obstruction.
Flexible Turning Space	The cubicle-shaped room has minimum dimensions of 150 x 150 cm.	Overcomes maneuvering difficulties and limited space. Allows 360° rotation within the chamber
Closed Confidentiality	Using curtains made of non-transparent material that extend to the floor, ensures visual secrecy even though the room is larger.	Maintain confidentiality

Table 15. Prototype concept 2

Key Features	Design Description	Addressed Needs
Open Counter-Style Design	The booths are designed without doors or full walls, but only as counters (tables) positioned facing the TPS wall. There is a high barrier (U-shaped partition).	Ensures entry and exit access is very fast and easy.
Two layers of Table Height	The voting table has two tabletops: one 70 cm high (for wheelchair users) and one 100 cm high (for normal users). The tabletops are operated by an automatic button that lifts the tabletop to the side.	Accommodating wheelchair and non-wheelchair users with a single solution
Corner Secrecy	The U-shaped partition extending forward ensures that voting is protected from side and rear views. Confidentiality is ensured by the protected seating position.	Overcoming confidentiality without the need for doors

Table 16. Prototype concept 3

Key Features	Design Description	Addressed Needs
Separate Cubicle Unit	A specially designed booth unit is positioned separately (not alongside standard booths). This booth has shorter legs and a lower table top.	A low cost and quick to implement solution that modifies the height of just one cubicle
Clear Work Zone	The table has leg room designed to allow a wheelchair to fit (under the table)	Allows users to approach the voting point without being obstructed by the table legs.
Double Confidentiality	The U partition is designed taking into consideration anthropometric data on the reach of the hand upwards.	Ensuring confidentiality is maintained by utilizing the room layout

The final step in the design ideation stage is design selection. Three voting booth design concepts will be selected. Table 17 shows the voting booth design selection.

Table 17. Design Selection

Design Criteria	Design Concept 1	Design Concept 2	Design Concept 3
Feasible	Easy to produce and low cost	Uses expensive new materials	Using standard materials, fast production
Desirable	Simply addresses one primary user need	Highly inclusive (disability access, comfort)	Standard design, functional but less attractive
Viable	Complies with current KPU regulations	Requires regulatory amendments due to dimensions	Technically feasible

Design concept 2 was chosen as the design to be prototyped, because design concept 2 is very feasible, desired by users and can be implemented easily and is very strong with the meaning of universal design implementation. As seen in Fig. 2, and Fig. 3, at this stage, the idea/concept is implemented into visual engineering forms Prototype (2D and 3D).

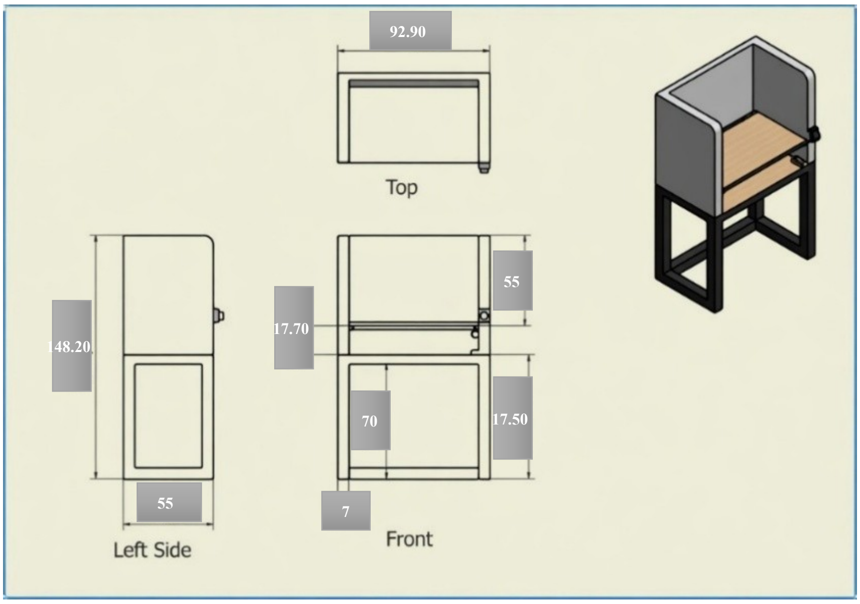

Fig 2. 2D Engineering Design

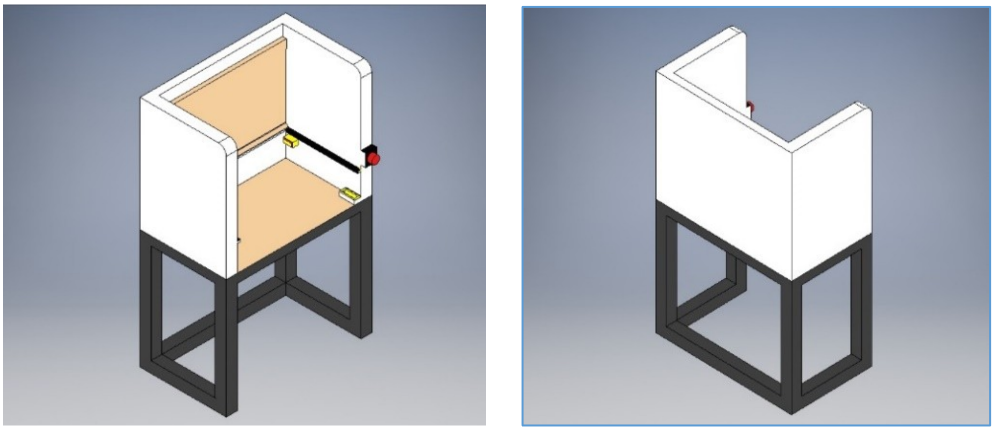

Fig 3. 3D Engineering Design

The design evaluation phase employed a qualitative approach through in-depth interviews with wheelchair users, the group with the most complex spatial and ergonomic challenges. This step was crucial for verifying the implementation of Universal Design principles, particularly regarding the dimensions of movement space and reach, which ensure full accessibility. In addition to technical testing, direct exploration of user perceptions served as a key indicator for measuring subjective aspects such as comfort, safety, and degree of independence when using the facility. Through this user-based evaluation, the performance of the voting booth design can be accurately validated to ensure the public facility is truly inclusive for all groups.

3.4. Election Voting Booth Design Based on Universal Design, Design Thinking, and Ergonomic

Through the integration of Design Thinking methods (as a workflow process) and Universal Design principles (as evaluation parameters), a voting booth design was created that accommodates the physical diversity of voters, from wheelchair users and the elderly to voters with extreme stature (very tall or short).

Specifically, the application of the Empathize and Define stages in Design Thinking revealed that the main obstacle in elections is not simply access to the polling station, but rather the physical interaction within the voting booth, which often ignores the anthropometric aspects of seated users. This finding was then translated into adjustable height features and ample legroom without barriers, fulfilling Universal Design principles 2 (Flexibility in Use) and 7 (Size and Space for Approach and Use).

This study fills a crucial gap in the inclusive design literature, which has tended to ignore the realities of the physical infrastructure of voting booths. From 2021 to 2025, election accessibility research was dominated by the development of e-voting and digital interfaces, as demonstrated in studies by Taib et al. (2024) dan Firdaus et al. (2025) which focused on touchscreen accessibility and biometric verification. However, this research confirms that no matter how sophisticated the software system developed, voting rights remain at risk if voters' primary physical interaction with the voting booth is neglected. Low-tech interventions in voting booth hardware have proven to be as important as software development in ensuring voter independence.

Although various organizations and countries have established accessibility guidelines, their implementation often falls short of comprehensive anthropometric parameters: (1) United States Election Commission (ADA) Standards: While the Americans with Disabilities Act (ADA) recognizes the needs of wheelchair users, the resulting modular units tend to be heavy and bulky. In contrast, our proposed design provides a low-effort solution (Universal Design Principle 6) for mobilization, which is crucial for Indonesia's logistically challenging geographic context (Americans, 2020). (2) IFES Standards: The International Foundation for Electoral Systems (IFES) guidelines, which emphasize the provision of low tables, often fail in practice due to their static nature. Our design goes beyond this standard by integrating adjustable height features (Universal Design Principle 2), accommodating a range of users from wheelchair users to very tall individuals (Lawrence Weru S.M., 2026). (3) Indonesian KPU Standards (KPU, 2023), the voting booth standards stipulated in KPU Regulations still rely on static dimensions (50x50x60 cm) placed on standard tables. Despite directives to provide low tables for voters with disabilities, implementation is often hampered by table designs that include cross-bracing or drawers.

Our proposed design offers the advantage of an integrated system between the booth and its support, which specifically eliminates legroom barriers in accordance with Universal Design 7 principles, ensuring independent accessibility that cannot be accommodated by simply using standard polling station tables. (4) European Union Perspective: In the European Union, although countries like Belgium and Lithuania have booth dimension requirements, research shows that inaccessibility and physical discrimination remain significant barriers. This indicates that even static dimension regulations in Europe do not fully address the needs of extreme stature diversity as addressed by these designs (Rabitsch et al., 2023). (5) The developing country perspective demonstrates a more pressing urgency. In Nigeria (2023 elections) and several South Asian countries, the absence of facilities such as ramps and appropriate tables forces voters with disabilities to compromise the confidentiality of their votes by relying on assistance or even abandoning their wheelchairs to access the booth. This phenomenon proves that physical design failure directly harms the principles of confidentiality and independence in democracy (Odeyemi, 2025; Aakash, 2026).

Despite the increasing digitalization of elections and the lack of accessible voting booths as a focus for improvements for people with disabilities, the physical aspect (voting booths) remains a key point of interaction in many developing countries, including Indonesia. Findings from this design suggest that low-tech interventions in voting booth hardware are as important as software development in ensuring independent voting rights.

3.5. Implications for Election Policy and Logistics Management in Indonesia

Redefining Logistics Standards: From Warehouse Efficiency to User Accessibility: These findings imply a critical need for the KPU to fundamentally revise the technical specifications for election logistics. To date, regulations regarding voting booth dimensions have tended to be dominated by considerations of storage efficiency, ease of distribution, and minimizing production costs. As a result, the resulting design parameters are often static and neglect anthropometric comfort. This study recommends that the KPU adopt Universal Design principles not as an exception (specific facilities for persons with disabilities), but as the standard norm for all voting booths. The policy implication is a paradigm shift from "one size fits all" to "one design for diversity." By integrating Universal Design standards into technical regulations (such as the revised KPU Regulation on voting equipment), the government is physically realizing the mandate of Law No. 8 of 2016 concerning Persons with Disabilities. This ensures that election infrastructure is no longer a barrier to political participation, but rather a facilitator of equality.

Holistic Standardization of Polling Station Facilities: The implications of this policy also extend to the layout and standardization of facilities within polling stations (TPS). Election organizers need to establish standards for "Barrier-Free Spaces," which include Circulation Zones: Ensuring the width of polling station entrances and exits conforms to internationally standard wheelchair turning radii. Adaptive Work Surfaces: Policies should mandate the use of variable-height voting booths to replace static tables, which are often unsuitable for voters with extreme physical stature or wheelchair users. Accessibility Audits: Encourage Bawaslu (Election Supervisory Agency) to incorporate "Inclusive Physical Parameters" as a field monitoring tool to ensure that facilities provided at the grassroots level truly meet established accessibility criteria.

Paradigm Shift: From "Assistance-Based" to "Independence-Based": Sociopolitically, this study suggests a radical shift in operational voting policies. Current policies still rely heavily on an "assistance-based" model, where polling station (KPPS) officers or assistants are allowed to assist voters with disabilities inside the voting booth. While well-intentioned, this practice carries a high risk of violating voter secrecy and harming voter dignity. By adopting a self-contained voting booth design, election policies can shift toward an "independence-based" approach. Designs that provide ample, unobstructed legroom and adjustable surface heights minimize the need for third-party intervention. This automatically strengthens the implementation of the LUBER (Direct, General, Free, and Secret) principle. Protecting vote secrecy for citizens with diverse physical characteristics is not merely a technical issue, but a fundamental effort to strengthen the integrity of Indonesian democracy, where every vote has an equal level of privacy and independence.

4. Conclusion

Based on study on the development of "Accessible Voting Booths with the Integration of Universal Design, Design Thinking, and Ergonomics," it can be concluded that this integrative approach has succeeded in producing an inclusive election facility design. Key findings indicate that ideal physical accessibility is achieved through a legroom height of 70 cm, a table top height of 75.5 cm and a table top height of 93.2 cm, and a table length of 92.9 cm, a width of 55 cm, and a cover height of 55 cm. These specifications have been empirically proven to accommodate the anthropometric diversity of voters from wheelchair users to individuals with extreme physical stature while minimizing physical effort and increasing independence in the voting process.

Theoretically, this study makes an important contribution by filling a research gap that has been overly dominated by digital accessibility (e-voting), demonstrating that physical infrastructure innovation remains a key foundation for inclusive democracy. Practically, the results of this research are positioned as technical guidelines for the Indonesian KPU in implementing the mandate of Law No. By adopting this standard, election organizers can effectively guarantee the "LUBER" (Direct, General, Free, and Secret) principle, ensuring that the confidentiality of every citizen's vote is protected without physical discrimination. Meanwhile as a future development step, further research is recommended to explore the use of lighter yet durable alternative materials to support efficient logistics distribution to remote areas. Furthermore, the integration of sensory support features, such as audio or tactile (Braille) devices, is needed to expand accessibility for blind and deaf voters. Finally, larger-scale prototype trials are highly recommended to evaluate the structural durability and time efficiency of the booths under actual election conditions.

Acknowledgment: The author would like to thank the General Election Commission (KPU) and the community of people with disabilities who have assisted in this study process.

Conflict of interest: The author declares that there is no conflict of interest regarding the research and publication of this manuscript.

Author Contribution: Author 1 designed the methodology and performed data analysis, and engineering design, Author 2 performed field data collection; Author 3 compiled the discussion and conclusions, Author 4 compiled and translated the manuscript.

Funding: This Study was funded by LPPM Muria Kudus University through the 2025 Higher Education Collaborative Research Grant with contract number: 635/LPM.UMK/B.07.226/XI/2025

References

Aakash, C. (2026). *For people with disabilities, there are barriers galore to right to voting*.

Alemande, D., Ummah, S. M., Priyanto, A. S., & Su-, I. (2024). *Accessibility of Political Participation for Different Abbility in The 2024 General Election in DKI Jakarta*. *8*(2), 78–84. https://doi.org/10.15294/upsj.v8i2.15837

Americans. (2020). *ADA Checklist for Polling Places*.

Astuti, D., & Suharto, D. G. (2021). Aksesibilitas Penyandang Disabilitas dalam Pemilu 2019 di Kabupaten Sleman. *Public Inspiration: Jurnal Administrasi Publik*, *6*(1), 29–41. https://doi.org/10.22225/pi.6.1.2021.29-41

Bai, Y., Kamarudin, K. M., & Alli, H. (2024). A systematic review of research on sitting and working furniture ergonomic from 2012 to 2022: Analysis of assessment approaches. *Heliyon*, *10*(7), e28384. https://doi.org/10.1016/j.heliyon.2024.e28384

Bitonti, A. (2022). Public interest. *The Palgrave Encyclopedia of Interest Groups*. https://doi.org/10.1007/978-3-030-44556-0_70

Bridger, R. S. (2017). *Introduction to Human Factors and Ergonomics*. CRC Press.

Celik, E., Sungur, A., & Turkyilmaz, C. C. (2025). Ergonomic Design for inclusive public spaces: a socio-demographic perspective on Child' s ergonomics in Umraniye and Kadikoy, Istanbul. *Journal of Asian Architecture and Building Engineering*, *24*(5), 4404–4419. https://doi.org/10.1080/13467581.2024.2399679

Chung, H. A., Park, J., Hwang, J. B., Kim, H. D., & Jung, H. S. (2016). Design of Ergonomic Front-Entry Sitting Toilet System for People using Wheelchairs. *Journal of the Ergonomics Society of Korea*, *35*(5), 425–437. https://doi.org/10.5143/jesk.2016.35.5.425

ESCAP. (2019). *Understanding accessibility*. United Nations Economic and Social Commission for Asia and the Pacific. https://doi.org/https://doi.org/10.18356/9789210046855c004

Firdaus, A., Ihsanul, M. S. C., Permana, F. C., & Murbani, A. W. (2025). The Constitutionality of E-Voting in the Transformation of Digital Democracy: A Normative Analysis and Implications for Electoral Legitimacy. *Journal of Indonesian Legal Studies*, *10*(1). https://doi.org/https://doi.org/10.15294/jils.v10i1.21193

Ghosh, N. (2022). Citizenship, rights and persons with disabilities in India. In *South Asia Multidisciplinary Academic Journal*. *journals.openedition.org*. https://journals.openedition.org/samaj/7924

Ginting, A. E., Nasution, M. A., & Kusmanto, H. (2021). Pola Rekrutmen Penyelenggara Pemilihan Umum Tingkat Kelompok Penyelenggara Pemungutan Suara di Kecamatan Medan Selayang Pada Pemilihan Umum Serentak Tahun 2019. *Perspektif*, *10*(2), 692–709. https://doi.org/10.31289/perspektif.v10i2.5101

Groulx, M., Freeman, S., & Lemieux, C. (2022). Accessible nature beyond city limits - A scoping review. *Journal of Outdoor Recreation and Tourism*, *37*(January). https://doi.org/10.1016/j.jort.2022.100490

Gupta, A., Yadav, M., & Nayak, B. K. (2025). A Systematic Literature Review on Inclusive Public Open Spaces: Accessibility Standards and Universal Design Principles. *Urban Science*. https://doi.org/10.3390/urbansci9060181

Hari, P. (2013). *Antropometri dan Aplikasinya*. Ghara Ilmu.

Harits, D., Kurnia, W. I., & Wibowo, N. A. (2025). Analysis of Antecedent Factors Influencing the Adoption and Conversion of Two-Wheeled Battery Electric Vehicles (BEVs) in East Kalimantan Province. In *Spektrum Industri*. https://doi.org/10.12928/si.v23i2.467

Hindayanti, H., Septiani, W., & Maulidya, R. (2024). Employee performance assessment model in survey service companies using analytical hierarchy process and Naïve Bayes. In *Spektrum Industri*. https://pdfs.semanticscholar.org/0751/1a3eb9ba2a09019ea43cc8e3eeeeefa1d39c.pdf

Iftikar, Z. Sutalaksana, Ruhana, A., T. (2006). *Teknik Perancangan Sistem Kerja* (2nd ed.). ITB.

Ihaab, S. (2022). Designing Accessible Elections: Recommendations from Disability Voting Rights Advocates. *Election Law Journal: Rules, Politics, and Policy*, *21*(1). https://doi.org/https://doi.org/10.1089/elj.2020.06

Inoue, M., & Nakajima, T. (2021). Universal Design Method Considering Physical Characteristics and Physical Load Based on Digital Human Model. *Journal of Advanced Manufacturing Technology.15*(3), 67–80. https://jamt.utem.edu.my/jamt/article/view/6223

Kirom, M. (2015). Sistem Informasi Geografis Pemetaan Suara Pemilukada Berbasis Open Source Di Kabupaten Jombang. *Edutic - Scientific Journal of Informatics Education*, *1*(1), 1–12. https://doi.org/10.21107/edutic.v1i1.400

KPU. (2023). *Peraturan Komisi Pemilihan Umum Nomor 14 Tahun 2023 tentang Perlengkapan Pemungutan Suara, Dukungan Perlengkapan Lainnya, dan Perlengkapan Pemungutan Suara Lainnya dalam Pemilihan Umum*.

Lawrence, W., S., M. (2026). *International Foundation for Electoral Systems (IFES).* The ENABLE Model.

Marisa, D., P. (2020). Rethinking inclusion and disability activism at academic conferences: strategies proposed by a PhD student with a physical disability. *Disability & Society*, *35*(1). https://doi.org/https://doi.org/10.1080/09687599.2019.1619234

Minet, A., Wentzel, D., Raff, S., & Garbas, J. (2024). Design thinking in physical and virtual environments: Conceptual foundations, qualitative analysis, and practical implications. *Technological Forecasting and Social Change*, *207*(February), 123596. https://doi.org/10.1016/j.techfore.2024.123596

Nguyen, T., T. (2022). Application of design thinking to implement innovation policy in teaching table tennis for students – the case of Vietnam National University, Hanoi. *Conhecimento & Diversidade Conhecimento & Diversidade *, *14*(35). https://doi.org/10.18316/rcd.v14i35.10692

Odeyemi, T. I. (2025). From exclusion to inclusion Assessing disability accessibility and participation in Nigeria ' s 2023 general elections. *Pluto Journals.* https://doi.org/10.13169/intljofdissocjus.5.3.0005

Putri, E. P., Parinov, I. A., & Wongloucha, C. (2024). Efficiency Evaluation in Indonesia's Quarrying Industry Using Variable Combinations DEA. In *Spektrum Industri*. https://journal3.uad.ac.id/index.php/spektrum/article/view/227/91

Rabitsch, A., Moledo, A., Lidauer, M., & Rabitsch, A. (2023). *Inclusive elections? The case of persons with disabilities in the European Union European Union. 0461*. https://doi.org/10.1080/10220461.2023.2275669

Rangga, F., Nangkula, U., Nazlina, S., Sumarni, I., & Ratri, W. (2020). Evaluation of universal design requirements application in public mosques in bandung. *Malaysian Journal of Public Health Medicine*. https://doi.org/10.37268/MJPHM/VOL.20/NO.SPECIAL1/ART.692

Ravensbergen, L., Van Liefferinge, M., Isabella, J., Merrina, Z., & El-Geneidy, A. (2022). Accessibility by public transport for older adults: A systematic review. *Journal of Transport Geography*, *103*(July). https://doi.org/10.1016/j.jtrangeo.2022.103408

Rinaldi, A., Viviani, S., & Busciantella-ricci, D. (2025). Urban Furniture Design Strategies to Build Healthy and Inclusive Neighborhoods. *Public health and healthcare.* https://doi.org/10.3390/su17030859

Robert, B. (2017). *Introduction to Human Factors and Ergonomics*. CRC Press. https://doi.org/https://doi.org/10.1201/9781351228442

Santana, S. B., Peña-Alonso, C., & Perez-Chacon Espino, E. (2021). Assessing universal accessibility in Spanish beaches. *Ocean and Coastal Management*, *201*(September 2020). https://doi.org/10.1016/j.ocecoaman.2020.105486

Sokhibi, A., Alifiana, M. A., & Asri, V. I. (2022). Ergonomic Design of Hand Sanitizer Dispenser Stand With Foot Pedal Model. In *Spektrum Industri*. https://doi.org/10.12928/si.v20i1.27

Sokhibi, A., Alifiana, M. A., & Vikha, I. A. (2020). Analysis of ergonomic lighting in the engineering faculty workspace of muria kudus university. In *Spektrum Industri*. academia.edu. https://www.academia.edu/download/121142521/pdf_21.pdf

Stephanus, A. (2024). *Banyak Penyandang Disabilitas Belum Terdaftar sebagai Pemilih Difabel*.

Syarif, M. I., Safriani, A., Islam, U., Alauddin, N., & Disabilitas, H. P. (2019). Pemilu di Indonesia. *Alauddin Law Development (Aldev)*, 18–25. https://doi.org/10.24252/aldev.v1i3.11894

Taib, R. B., Vivian, B. T., Asyraf, K., & Roslan, B. (2024). *E-Voting: A Bibliometric Analysis of Scopus*. *Hong Kong Journal of Social Sciences*. *63*. https://doi.org/10.55463/hkjss.issn.1021-3619.63.38

Tutal, O. (2018). Universal Access in Historic Environment and Accessibility of The Haci Hasan Mosque in Eskisehir. *Iconarp International J. of Architecture and Planning*, *6*(1), 126–141. https://doi.org/10.15320/iconarp.2018.41

Virendrakumar, B., Jolley, E., Badu, E., & Schmidt, E. (2018). Disability inclusive elections in Africa: a systematic review of published and unpublished literature. *Disability & Society*, *33*(4), 509–538. https://doi.org/10.1080/09687599.2018.1431108

Watchorn, V., Hitch, D., Tucker, R., Frawley, P., Aedy, K., & Grant, C. (2023). Evaluating universal design of built environments: an empirical study of stakeholder practice and perceptions. *Journal of Housing and the Built Environment*, *38*(3), 1491–1510. https://doi.org/10.1007/s10901-022-09981-x

Wijk, R. van, Baudoin, S. J. M., Ejiogu, B., Regmi, U., & Korfage, I., J. (2025). From words to action: the development of the Neglected Tropical Disease Inclusion Score Card (NISC). In *Infectious Diseases of Poverty*. *Springer*. https://doi.org/10.1186/s40249-025-01340-6