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MORALITY BEFORE KNOWLEDGE

SahabatInklusi: A catalyst for change toward a more inclusive and disability-friendly Indonesia through artificial intelligence (AI) and computer vision

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ABSTRACT

Background: People with disabilities represent one of the world's largest marginalized groups. In Indonesia, despite progressive legislation, significant implementation gaps persist in accessibility. Current technological solutions are often fragmented, failing to provide comprehensive support for diverse user needs. **Methods**: This research adopts a conceptual design-based approach, combining a systematic literature review, policy analysis, and system design thinking. The methodological framework integrates the Pentahelix multi-stakeholder collaboration model with Community-based development (CBD) principles. A SWOT analysis was conducted to evaluate the platform's strategic positioning and implementation feasibility. **Findings:** The conceptual framework for "SahabatInklusi" incorporates four synergistic features: real-time sign language translation using Computer Vision and deep learning, AI-powered navigation assistance with voice commands, interactive mapping of accessible public facilities, and an integrated emergency response system. The SWOT analysis reveals significant strengths in technological integration and a multi-disability approach, while identifying critical dependencies on digital infrastructure and data security. **Conclusion**: SahabatInklusi represents a paradigm shift in assistive technology design, positioning digital innovation as a catalyst for social inclusion rather than merely a technical solution. The platform demonstrates how integrated AI can transform accessibility into a central component of the digital ecosystem, thereby contributing to achieving Sustainable Development Goal 9 (Industry, Innovation, and Infrastructure) in Indonesia. **Novelty/Originality of this article:** The research introduces a novel integration of AI and Computer Vision within an inclusive design framework that incorporates multi- stakeholder collaboration models. This holistic approach addresses both the technological and social dimensions of accessibility, offering a replicable framework for developing comprehensive disability-inclusive solutions in emerging markets.

KEYWORDS: artificial intelligence; disability inclusion; accessible technology.

1. Introduction

The concept of disability has undergone a profound evolution in international discourse, moving away from a purely medical or charitable model towards a framework grounded in human rights and social inclusion. Disability, as defined by the UNESCO Institute for Statistics (2025), encompasses a broad range of impairments, activity limitations, and participation restrictions. This definition is pivotal as it reframes disability

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not as an individual deficit, but as a multifaceted phenomenon arising from the interaction between a person's inherent conditions and the environmental and attitudinal barriers erected by society. It is not solely a physical condition but also includes sensory, intellectual, and mental limitations that hinder full participation in social life. This shift in perspective, often termed the social model of disability, posits that if the barriers are removed, the limitation in participation is alleviated. This modern understanding is powerfully codified in Indonesia's landmark Law No. 8 of 2016 on Persons with Disabilities, which defines a person with a disability as anyone who experiences long-term physical, intellectual, mental, or sensory impairments which, in interaction with various barriers, may restrict their full and effective participation in society on an equal basis with others. This legal definition is crucial because it legally obligates the state and society to proactively identify and dismantle these barriers, a task that remains a monumental challenge.

The scale of this challenge is both global and local, underscoring its urgency. Globally, the World Health Organization (WHO, 2023) estimates that 1.3 billion people, or one in six individuals, experience significant disabilities, constituting the world's largest marginalized group. This is not a distant issue but a pressing domestic reality. In Indonesia, the Intercensal Population Survey/*Survei Penduduk Antar Sensus* (SUPAS) 2015 and the National Socioeconomic Survey/*Survei Sosial Ekonomi Nasional* (SUSENAS) 2019 reported an increase in the number of individuals with disabilities from

21.1 million (8.6%) to 23.3 million (9%), with 5.7 million experiencing severe disabilities (TNP2K, 2019; TNP2K, 2020). This rising trend, potentially linked to better diagnostics, an aging population, and broader awareness, highlights a growing segment of the population whose rights to equitable participation are not fully realized. A granular look at the data reveals a deeply uneven distribution; the 2019 Susenas data shows a staggering 41.9% of Indonesians aged 60 and above are persons with disabilities, pointing to a critical intersection between disability and aging that demands targeted policy responses. Despite ongoing policy efforts, challenges persist in realizing equitable participation for people with disabilities, particularly in access to quality education, decent employment, and essential public services.

Recognizing these challenges, the Indonesian government has introduced several initiatives to enhance inclusivity. The cornerstone is Law No. 8 of 2016, which was further elaborated by Government Regulation/*Peraturan Pemerintah* (PP) No. 70 of 2019 on the Planning and Implementation of the Fulfillment of the Rights of Persons with Disabilities and PP No. 42 of 2020 on Accessibility to Employment for Persons with Disabilities. These laws collectively articulate a comprehensive vision for accessibility in public services, infrastructure, and employment, mandating inclusive design and non-discrimination. However, the implementation remains limited, revealing a stark "implementation gap." A glaring example lies in healthcare access. For instance, only 38.1% of persons with disabilities have access to the National Health Insurance/*Jaminan Kesehatan Nasional* (JKN), while among the lowest 40% income group, only 46.2% are registered as premium assistance beneficiaries/*Penerima Bantuan Iuran Jaminan Kesehatan Nasional* (PBI-JKN) (TNP2K, 2019). This means that over half of the most economically vulnerable persons with disabilities are excluded from a program designed precisely for their protection. This reflects a significant disparity between formal commitments and actual field execution, often due to bottlenecks in data integration, local government capacity, and outreach mechanisms.

This implementation gap is physically manifested in the very infrastructure of Indonesian cities. Accessibility in public infrastructure also remains insufficient. Foundational research by Thohari (2014) provides concrete evidence of this exclusion, finding that 85% of 125 public facilities in Indonesia lack proper wheelchair ramps, and 83% fail to provide accessible toilets, while the remaining 17% that do provide them often do not meet standards. This data, though from a localized study, is symbolic of a national issue. The consequences are profound: a person who uses a wheelchair cannot enter a government office, a blind individual cannot navigate broken pavements safely, and a person with limited mobility cannot use a public toilet with dignity. Such structural

limitations hinder independence and dignity for persons with disabilities, reinforcing social inequality by physically barring them from the spaces of civic and social life.

To address these multifaceted challenges, the Sustainable Development Goals (SDGs) 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation" serve as a critical framework. SDG 9 is particularly relevant as it explicitly highlights the role of technological and infrastructural innovation in promoting equity and participation for all. It calls for a fundamental rethinking of how we build our world, both physically and digitally. This aligns with the findings of the UN Flagship Report on Disability and SDGs (2018), which emphasizes that people with disabilities are often excluded from the development process due to data gaps and insufficient participatory design in infrastructure planning. When the voices of persons with disabilities are absent from the planning table, the resulting infrastructure and technologies are almost invariably exclusionary.

Therefore, inclusive innovation must extend beyond physical structures to include digital ecosystems that empower individuals with disabilities. In the 21st century, access to information and communication technology is not a luxury but a prerequisite for full participation. In this context, technology functions as both a medium for accessibility and a vehicle for social change. It can compensate for functional limitations and dismantle information barriers, thereby acting as a powerful equalizer. Building upon this notion, the authors propose SahabatInklusi, a conceptual model of a digital platform designed to bridge accessibility gaps through Artificial Intelligence (AI) and Computer Vision technologies.

SahabatInklusi seeks to serve as a catalyst that transforms technological innovation into a driver of inclusivity. The platform is conceived not as a mere tool, but as a digital companion that embodies universal design principles, ensuring accessibility regardless of users' physical or cognitive abilities. Its integrated approach is key; By integrating real-time language translation, AI-driven navigation, accessible facility mapping, and emergency support, SahabatInklusi aspires to enhance mobility, communication, and safety for people with disabilities in a holistic manner, addressing multiple barriers simultaneously.

This study thus aims to conceptualize SahabatInklusi as a technological innovation aligned with SDG 9. It delves into the practical question of how AI and Computer Vision can be leveraged to support accessibility, moving beyond theoretical potential to a concrete design proposition. Furthermore, it investigates what theoretical frameworks underpin inclusive design, drawing from disability studies and sociotechnical systems theory, and explores the critical question of how multi-sectoral collaboration can sustain such innovation through models like Pentahelix and Community-based development. The conceptual foundation of this research is informed by disability studies, inclusive technology literature, and sustainable development theory, weaving these threads together to present a comprehensive vision for a more inclusive digital future in Indonesia.

2. Methods

2.1 Research design

This study adopts a conceptual research design combined with a design-based approach to explore the intersection between technology, accessibility, and inclusive development. This methodological choice is particularly suited to the nascent stage of inclusive digital platform development in the Indonesian context, where the primary need is to establish a robust theoretical and architectural foundation before empirical testing (Brown & Wyatt, 2010). Unlike empirical research that focuses on field data collection, conceptual research integrates theoretical perspectives, policy frameworks, and design analysis to construct a comprehensive model of innovation. The design-based method, often utilized in educational technology and social innovation, is employed to conceptualize SahabatInklusi as an inclusive technological solution that aligns with the principles of Sustainable Development Goal 9 (SDG 9), namely, inclusive industrialization and

sustainable innovation. This approach allows for iterative refinement of the concept based on logical deduction and synthesis of existing knowledge, rather than primary data.

The research design is structured around three interconnected stages: conceptual foundation, system conceptualization, and analytical evaluation. The first stage involves conducting a systematic literature review on disability inclusion, digital accessibility, AI and Computer Vision applications, and national/international disability policies, with the aim of mapping the existing scholarly landscape to identify key theories, successful case studies, and persistent gaps. It specifically examines the principles of Universal Design for Learning (UDL) to inform adaptable user interfaces (CAST, 2018) and explores precedents in global assistive technology to avoid reinvention and leverage proven design patterns. Building on these theoretical insights, the second stage focuses on designing the conceptual framework of SahabatInklusi, including its core features, interaction models, and technical components based on inclusive design principles. This phase translates prior findings into a tangible system architecture by defining user stories for different disability profiles, developing accessible user interface wireframes (e.g., high contrast modes and screen reader compatibility), and outlining the technical specifications for the AI modules, thereby ensuring the platform's engineering feasibility.

The third stage employs qualitative analysis through the Pentahelix Collaboration Model and Community-based development (CBD) framework, complemented by a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats), to evaluate the feasibility and sustainability of the proposed innovation. This stage extends beyond technical design to assess the social, economic, and operational viability of SahabatInklusi. The Pentahelix model ensures a multi-stakeholder perspective, while the CBD framework grounds the evaluation in the needs of the end-user community. Through this integrated approach, the research connects theory and practice, ensuring that SahabatInklusi is grounded in both scientific knowledge and social relevance, and ultimately producing a blueprint that is technologically robust and socially responsive.

2.2 Conceptual framework

The conceptual framework of SahabatInklusi is guided by two major theoretical perspectives that provide a complementary foundation for the platform's development: Inclusive Design Theory, which emphasizes universal access and usability regardless of users' physical or cognitive abilities. This theory, sometimes used interchangeably with Universal Design, posits that designing for the broadest possible range of users from the outset benefits everyone (Story et al., 1998). For SahabatInklusi, this means the platform is not an afterthought or a specialized tool for a few, but a mainstream application whose core architecture embraces diversity. This translates into features like customizable font sizes, voice-controlled navigation, alternative text for images, and a simplified user flow that can be understood and operated through multiple modalities.

In addition, Sociotechnical Systems Theory, which views technology as a system co-constructed with human, social, and organizational components. This theory argues that the success of a technological intervention is inextricably linked to the social system in which it is embedded (Trist & Bamforth, 1951). Applying this to SahabatInklusi means that the platform's effectiveness is not solely determined by its code but also by factors such as digital literacy among users, supportive government policies, sustainable business models for maintenance, and cultural acceptance of assistive technology. This theoretical lens forces the design to consider the entire ecosystem, not just the software.

The framework integrates AI-driven technology with social innovation through four main modules, each addressing a specific dimension of accessibility: AI-Powered Sign Language Translator, which enables two-way communication between the hearing-impaired and general users through real-time translation using Computer Vision and Neural Text-to-Speech (TTS) technology. It leverages advanced models like MediaPipe for hand tracking and pose estimation to accurately interpret signs, moving beyond static gesture recognition to dynamic, continuous sign language understanding. In addition, AI-Based

Navigation Assistant, which provides auditory navigation and safety guidance for users with visual impairments, utilizing Natural Language Processing (NLP) and speech recognition. It can be conceptualized to integrate with open-source mapping libraries and incorporate data from OpenStreetMap (OSM, 2023), which often contains valuable community-contributed accessibility information about sidewalks, crossings, and obstacles.

Furthermore, Accessible Facility Mapping, which displays a real-time map of disability-friendly infrastructure, including wheelchair-accessible paths, ramps, and restrooms. Its conceptual design includes a crowdsourcing mechanism that allows users to verify and update accessibility data, thereby creating a living, community-driven database. This addresses the critical issue of data scarcity highlighted in the introduction. Finally, Emergency Assistance Feature, which offers immediate access to emergency services via integrated contact buttons or voice commands. The framework proposes a tiered alert system that can notify predefined contacts (family, friends) and relevant authorities simultaneously, while also transmitting the user's precise location. The design considers privacy concerns by ensuring that location data is only shared during an active emergency trigger.

This integrated framework, supported by the dual pillars of Inclusive Design and Sociotechnical Systems theories, positions SahabatInklusi as a holistic platform that addresses multidimensional barriers—communication, mobility, and safety—while promoting independence and equal participation. It is a system designed not just to function technically, but to thrive within the complex social fabric of Indonesia.

2.3 The pentahelix collaboration model

To ensure the long-term sustainability and societal impact of SahabatInklusi, the project is grounded in the Pentahelix Collaboration Model. This model moves beyond traditional top-down or siloed approaches by emphasizing the dynamic synergy and co-creation between five key stakeholders: academia, business, government, community, and media (Kompolla, 2017). The Pentahelix framework is particularly apt for complex socio-technical innovations like SahabatInklusi, as it recognizes that technological viability alone is insufficient; success depends on a supportive ecosystem that fosters adoption, adaptation, and continuous evolution (Carayannis & Campbell, 2009). This model facilitates a holistic and multi-stakeholder engagement process throughout the design, implementation, and scaling phases. The specific roles and contributions of each helix are detailed as follows. Academia contributes theoretical insights, research validation, and usability evaluation to ensure that the application aligns with evidence-based practices. Universities and research institutes serve as the knowledge backbone of the project. Their role extends to conducting foundational research on human-computer interaction (HCI) for users with diverse abilities, validating the accuracy of AI models like the sign language translator, and leading longitudinal studies to measure the platform's social impact. Furthermore, academia acts as a talent incubator, equipping students with the skills to contribute to and maintain such inclusive technologies, thereby creating a pipeline of future innovators (Etzkowitz & Leydesdorff, 2000).

Alongside academia, the Business Sector provides essential financial support, technological resources, and opportunities for social entrepreneurship through inclusive innovation. This helix includes technology companies, venture capitalists, and corporate social responsibility (CSR) arms. Their involvement is crucial for funding development, providing cloud computing infrastructure for the AI services, and offering expertise in software development and scalability. Beyond philanthropy, businesses can explore sustainable revenue models, such as B2B services for companies seeking to enhance their own accessibility or premium features for users. This engagement allows businesses to tap into the disability market, the so-called "Purple Economy," which represents significant untapped economic potential (G3ict, 2016).

Within the regulatory domain, the government functions as a policy enabler by establishing supportive regulations, accessibility standards, and digital inclusion

frameworks. This includes national bodies like the Ministry of Social Affairs and local government units. The government's role is to create a conducive environment by enforcing existing laws such as UU No. 8 of 2016, integrating SahabatInklusi into national digital inclusion strategies, and providing public funding or tax incentives to support its development and adoption. Government agencies can also act as key data providers, sharing geospatial information on public infrastructure to enrich the platform's accessibility mapping features, thereby bridging the data gap between public policy and on-the-ground reality.

Equally important, the Community, especially persons with disabilities and their representative organizations *(OPDs - Organisasi Penyandang Disabilitas)*, act as both users and co-developers, ensuring that technological outputs reflect real needs and lived experiences. This is the most critical helix, embodying the principle "Nothing About Us Without Us." Their involvement is operationalized through participatory design workshops, beta testing programs, and continuous feedback loops. OPDs help in contextualizing the technology to Indonesia's diverse cultural and linguistic landscape, including different dialects of Indonesian Sign Language/*Bahasa Isyarat Indonesia* (BISINDO). This direct engagement ensures the platform is not just usable, but also relevant and empowering, fostering a sense of ownership that is vital for long-term adoption (Sanders & Stappers, 2008).

Complementing these actors, Media plays a crucial role in promoting awareness, disseminating knowledge, and fostering cultural acceptance of disability inclusion. Traditional and new media outlets can shape public perception by highlighting the capabilities and contributions of persons with disabilities, rather than portraying them as objects of pity. Strategic media campaigns can drive downloads and usage of SahabatInklusi, while also holding other stakeholders, particularly government and business, accountable for their commitments to inclusion. By telling the stories of users whose lives have been improved by the platform, media can help normalize the use of assistive technology and challenge deep-seated social stigmas.

The Pentahelix model, through its emphasis on iterative interaction and mutual value creation among these five helixes, thus ensures that SahabatInklusi is not only technologically viable but also socially embedded, economically sustainable, politically supported, and culturally accepted. It transforms the platform from a standalone application into a robust, ecosystem-driven solution for inclusive development.

2.4 Community-based development (CBD) approach

While the Pentahelix model outlines the broader ecosystem, the Community-based development (CBD) framework is incorporated at the project's core to operationalize participatory design and foster genuine local ownership. CBD is a bottom-up approach that positions the community not as passive recipients of a pre-determined solution, but as the central agents of change (Mansuri & Rao, 2013). In the context of SahabatInklusi, this means the disability community is not viewed merely as beneficiaries but as active contributors, co-designers, and evaluators to the creation and evolution of the platform. This philosophy is encapsulated by the disability rights motto, "Nothing About Us Without Us," ensuring the technology is shaped by the lived expertise of its intended users from the very beginning.
This approach is systematically implemented through three key, iterative phases:

Participatory Need Assessment serves as the initial phase, moving beyond traditional surveys to identify accessibility challenges through deep, qualitative engagements. Methods include facilitated Focus Group Discussions (FGDs) with diverse disability groups (e.g., persons with visual, hearing, physical, and intellectual impairments), in-depth interviews with caregivers and OPD leaders, and contextual inquiries where researchers observe the daily routines and environmental barriers faced by individuals (Chambers, 1997). For example, workshops would be held to map out specific navigation hazards for wheelchair users in Malang or communication breakdowns faced by the deaf community when accessing public services. This phase ensures that the problem definition itself is accurate

and comprehensive, preventing the development of solutions for misunderstood or non-existent problems.

This is followed by the Co-Design Process, which involves collaboratively designing features that reflect the diverse needs of users with different disabilities. It transforms users from subjects of research into partners in creation. Activities include (a) Participatory Wireframing and Prototyping: Using tactile, audio, or visual tools to allow non-technical users to sketch and model their ideal interface; (b) Iterative Usability Testing: Early and frequent testing of low-fidelity and high-fidelity prototypes with community members, where their feedback directly influences the next design iteration. This is crucial for refining complex features like the AI sign language translator, ensuring it accurately captures local signs and cultural nuances; and (c) Accessibility Jams: Collaborative workshops where developers, designers, and community members work together to solve specific accessibility challenges, fostering mutual learning and empathy (Steen, 2013). This process ensures that the final product is not only functional but also intuitive, culturally appropriate, and embraced by the community.

The next phase focuses on capacity Building and digital literacy, recognizing that a tool is only as powerful as a user's ability to wield it and emphasizing continuous training to ensure long-term sustainability. This involves (a) developing tailored training modules in accessible formats (e.g., braille, audio, easy-read); (b) conducting "train-the-trainer" programs to empower OPD members to become digital literacy champions within their own networks; (c) establishing community help-desks or peer-support networks to provide ongoing technical assistance; and (d) this empowerment is critical to bridge the digital divide and prevent the unintentional exclusion of those with lower technological proficiency, thereby ensuring the platform's benefits are widely accessible (Warschauer, 2004).

By integrating the CBD approach throughout the project lifecycle, SahabatInklusi moves beyond a transactional model of development to one of transformation. It promotes empowerment and inclusivity, ensuring that the technological solutions evolve with the users they aim to serve, fostering a sense of ownership that is the true bedrock of long-term sustainability and impact.

2.5 Data sources and analytical method

This conceptual study is fundamentally anchored in a rigorous and systematic review of secondary data sources. This approach is chosen to construct a comprehensive evidence base that informs the design and strategic positioning of SahabatInklusi without the time and resource constraints of primary data collection at this initial stage (Johnston, 2014). The data triangulation strategy draws from a diverse array of credible sources, including:
(1) Academic Journals: Sourced from databases like Scopus, ScienceDirect, and Google Scholar, focusing on fields such as human-computer interaction (HCI), disability studies, and computer science. (2) Government Reports and Policy Documents: Key documents from Indonesian institutions like BPS (*Badan Pusat Statistik*), TNP2K (*Tim Nasional Percepatan Penanggulangan Kemiskinan*), and various ministries, providing crucial local context and regulatory frameworks. (3) International Organizations: Publications from globally recognized bodies such as the World Health Organization (WHO), UNESCO, the United Nations, and the World Bank, which offer standardized data, global best practices, and theoretical frameworks.

To ensure the quality and relevance of the literature, a structured literature selection criteria was implemented: (1) Temporal Relevance: Priority was given to publications from the last ten years (2014–2024) to capture the most current trends, technologies, and policy landscapes related to disability inclusion, AI applications, and SDG implementation. Seminal theoretical works outside this window were included where a foundational context was required. (2) Source Credibility: A strict preference was maintained for peer-reviewed articles in reputable journals or official policy-based reports from governmental and intergovernmental organizations with verified credibility. This minimizes bias and ensures

that the analysis is based on validated knowledge (Xiao & Watson, 2019). (3) Thematic Focus: The selection was filtered to include only literature that directly addressed the core themes of the study: digital accessibility, assistive technologies, the Pentahelix/CBD models, and the socio-technical challenges of implementing SDG 9 in a developing context.

The analysis employs qualitative content analysis as the primary method to synthesize the collected knowledge. This involved a systematic process of coding and categorizing the textual data from the selected literature. The process included: (1) Identifying key concepts and themes (e.g., "barriers to accessibility," "AI for sign language," "participatory design"). (2) Categorizing and comparing findings across different sources to identify patterns, consensus, and contradictions. (3) Synthesizing the information to build a coherent argument, identify critical gaps in existing accessibility technologies, and justify the conceptual design choices for SahabatInklusi (Elo & Kyngäs, 2008).

Furthermore, to translate the conceptual design into a strategic roadmap, a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) is applied. This structured planning method provides a clear-eyed assessment of SahabatInklusi's strategic position in the digital inclusion landscape (Helms & Nixon, 2010). The analysis: (1) Strengths: Evaluates the internal, positive attributes of the platform itself (e.g., technological integration, multi-disability approach). (2) Weaknesses: Critically assesses internal limitations (e.g., cost, digital divide). (3) Opportunities: Identifies external factors in the environment that could be leveraged for advantage (e.g., supportive policies, potential partnerships). (4) Threats: Recognizes external challenges that could jeopardize success (e.g., competition, data privacy risks). The combination of qualitative content analysis and SWOT analysis ensures that the study is not only descriptive but also analytical and strategic, providing a robust foundation for both the conceptualization of SahabatInklusi and its future development and implementation.

2.6 Ethical considerations

As a conceptual study, this research does not involve direct human participants or primary data collection, thereby circumventing the need for formal institutional review board (IRB) approval at this stage. However, the highest standards of academic and research integrity are upheld through rigorous ethical compliance. This is maintained by ensuring all secondary data, ideas, and direct quotations from existing literature are properly cited and credited according to the APA 7th Edition referencing standard, thereby preventing plagiarism and acknowledging the intellectual contributions of other scholars.

Beyond academic integrity, the proposed SahabatInklusi system concept is designed with a foundational commitment to ethical technology use, anticipating and addressing potential ethical dilemmas that may arise during future development and deployment. This proactive ethical framework is built on three core principles: (1) Data Privacy and Security: Recognizing that the platform will handle sensitive user data. Including location, health information (in emergency contexts), and communication patterns. Tthe conceptual design mandates robust data protection measures. This includes proposing principles of data minimization (collecting only essential data), end-to-end encryption for sensitive communications, and transparent user controls over data sharing preferences, in alignment with emerging global standards like Indonesia's Undang-Undang Perlindungan Data Pribadi (PDP) (Greenleaf, 2022). Users must have clear information and choice regarding how their data is used. (2) Accessibility Equity: The ethical imperative of the project is to bridge the digital divide, not widen it. Therefore, the concept explicitly addresses the risk of creating a "two-tier" system where only those with high-end smartphones and stable internet can benefit. The design philosophy incorporates principles of progressive enhancement, ensuring core functionalities remain usable on basic devices and in low-bandwidth environments. Furthermore, the conceptual business model explores partnerships to provide subsidized data plans or device access for low- income users with disabilities, ensuring equitable access (Gupta et al., 2023). (3) Non-Discriminatory and Bias-Free Design: AI systems can perpetuate and amplify existing societal biases. The conceptual

framework for SahabatInklusi explicitly acknowledges this risk, particularly for the sign language translator and navigation assistant. It proposes mitigation strategies such as training AI models on diverse, representative datasets that include various Indonesian ethnicities, gender expressions, and disability types to minimize algorithmic bias (Buolamwini & Gebru, 2018).

Furthermore, the design commits to continuous bias auditing and incorporating feedback mechanisms for users to report erroneous or discriminatory outputs, ensuring the technology serves all users fairly. By embedding these ethical considerations into the conceptual blueprint, SahabatInklusi is positioned not merely as a technological tool, but as a responsible and trustworthy platform. This foresight aims to build user trust and create a solid ethical foundation for all subsequent stages of development and implementation.

3. Results and Discussion

3.1 Conceptual design of sahabatinklusi

The conceptual design of SahabatInklusi represents a multi-feature mobile application aimed at fostering digital accessibility and inclusion for persons with disabilities in Indonesia. The design focuses on integrating Artificial Intelligence (AI), Computer Vision, and user-centered design principles within a unified platform, creating a cohesive ecosystem rather than a collection of disparate tools. This holistic approach is critical, as persons with disabilities often face intersecting challenges that cannot be addressed by single-point solutions (Shinohara & Wobbrock, 2016). The application comprises four primary features designed to address the fundamental communication, mobility, and safety challenges faced by people with diverse disabilities, thereby acting as a digital Swiss Army knife for accessibility.

3.1.1 Sign language translation system

This feature leverages Computer Vision and Deep Learning algorithms, specifically Convolutional Neural Networks (CNN) for spatial feature extraction from video frames and Long Short-Term Memory (LSTM) models for temporal sequence modeling—to interpret dynamic hand gestures, facial expressions, and body movements, converting them into text or synthetic speech in real-time (Koller et al., 2019). Conversely, it transforms spoken language into visual sign outputs or articulated text using advanced Neural Text-to-Speech (TTS) and Text-to-Sign technologies. This bidirectional system is designed to be context-aware and capable of handling the linguistic nuances of Bahasa Isyarat Indonesia (BISINDO), which is widely used by many in Indonesia's Deaf community. By enabling fluid communication between hearing-impaired users and non-signers, it bridges profound linguistic gaps and promotes genuine social inclusion in educational, professional, and public settings.

3.1.2 AI-based navigation assistant

Designed primarily for visually impaired users, this feature uses speech recognition and Natural Language Processing (NLP) to understand complex voice commands such as “Show me the safest walking route to (destination), avoiding construction.” The assistant then provides real-time, auditory guidance that is rich in detail and orientation cues, e.g., “Turn left after 50 meters; you will find a tactile paving strip. The crosswalk signal is ahead on your right.” It integrates data from sources like OpenStreetMap and specialized accessibility databases to identify and warn about obstacles, crowded areas, or inaccessible paths. This system significantly enhances mobility autonomy, reducing dependence on others and improving the user’s confidence and safety in navigating complex public spaces, a key factor for independent living (Brock et al., 2022).

3.1.3 Accessible facility mapping

This component provides an interactive, community-augmented map that identifies and rates nearby disability-friendly public facilities. It goes beyond static databases by incorporating a crowdsourcing mechanism that allows users to verify, update, and add new information about facilities, including ramps, accessible toilets, hearing loops, and Braille signage. By combining AI-driven geolocation tracking with this dynamic accessibility data, users can plan personalized routes that suit their specific physical and sensory needs. The map includes a sophisticated filtering option to categorize facilities by disability type (e.g., physical, visual, auditory, cognitive), ensuring a user with a wheelchair can find a different set of amenities than a user who is deaf. This feature directly addresses the critical information gap highlighted in the problem statement.

3.1.4 Emergency assistance system

A critical feature that connects users to emergency services, predefined trusted contacts, or nearby community responders. Through one-tap or voice activation, the system can instantly transmit the user's precise GPS location and a pre-filled profile containing essential disability-related information (e.g., "non-verbal," "uses wheelchair") to expedite appropriate assistance. For non-urgent but important incidents, such as discrimination or encountering a broken accessibility feature, an embedded, accessible complaint form can be filled out using voice-to-text. This dual approach ensures both immediate personal safety and facilitates long-term advocacy by systematically documenting accessibility violations (Morris et al., 2018).

Together, these four features constitute a cohesive, adaptive, and resilient system that aligns cutting-edge technological innovation with deeply human-centered values. They are designed to interoperate; for instance, the navigation assistant can guide a user to an accessible facility from the map, and the emergency system can be activated seamlessly from any screen. The conceptual architecture of SahabatInklusi emphasizes the interconnectivity of these features, demonstrating how data flows between modules to create a unified user experience that is greater than the sum of its parts.

3.2 Comparative analysis with existing solutions

The landscape of inclusive digital technology in Indonesia is nascent but growing, reflecting a rising awareness of disability rights. While various inclusive technology applications have been developed locally, such as Disability Companion/*Teman Disabilitas* (TeDi) from Universitas Padjadjaran and EmpatiKu, they often function as pioneering yet isolated solutions. TeDi, for instance, is a commendable initiative that primarily focuses on the Deaf and hard-of- hearing community, offering features like sign language translation and text-to-speech. EmpatiKu, on the other hand, serves as an informational platform aimed at raising awareness and providing educational content about disabilities. However, a critical analysis reveals that most of these existing initiatives are limited to specific disability groups or function as single-purpose utilities, thereby failing to address the complex, overlapping needs of the wider disability community (Firmansyah et al., 2022). This fragmentation forces users to juggle multiple applications, leading to a cumbersome and inefficient experience.

To clearly delineate the innovative position of SahabatInklusi, a systematic comparison with existing disability support applications is presented in Table 1. This comparison evaluates the presence of core features that are essential for comprehensive digital inclusion. By examining the extent to which each platform integrates these functionalities, the analysis highlights critical gaps in current applications. It also demonstrates how SahabatInklusi addresses these limitations through a more integrated and inclusive approach.

Table 1. Comparison of SahabatInklusi with existing disability support applications

Feature	TeDi	Empatiku	SahabatInklusi
Real-time sign language translator	✓	✗	✓
AI-Based navigation with voice commands	✗	✗	✓
Disability-friendly public facility map	✗	✓	✓
Integrated emergency assistance	✗	✗	✓
Multi-disability approach	✗	✗	✓

The table shows that SahabatInklusi distinguishes itself through a comprehensive, integrative approach. Unlike existing solutions that target specific impairments in a siloed manner, SahabatInklusi is architected from the ground up to encompass multi-disability usability. It uniquely embeds safety (emergency assistance), mobility (AI navigation), and communication (sign language translation) within one unified platform, alongside a dynamic, community-driven resource map. This integration is vital; for example, a user with a physical disability can use the facility map to find an accessible route, the navigation assistant to guide them there, and the emergency button as a safety net—all within a single, consistent interface. This holistic model moves beyond isolated tools to create a synergistic support system.

This integrative model firmly situates the app within the emerging framework of inclusive smart technology ecosystems (Poerwanti et al., 2024), which advocate for digital environments that are universally accessible by design. By consolidating critical functionalities, SahabatInklusi reduces the digital burden on users, enhances overall utility, and presents a more sustainable and scalable model for digital inclusion. It addresses the core critique of the current landscape, fragmentation, by offering a centralized platform that acknowledges and serves the multifaceted nature of daily life for persons with disabilities in Indonesia.

Table 2. SWOT analysis of SahabatInklusi

Strengths	Weakness
1. Integration of AI, Computer Vision, and accessibility principles in one unified system. 2. Supports multiple disabilities and promotes independent mobility. 3. Enhances user safety through real- time emergency connectivity.	1. Dependence on stable internet connection and high-end mobile devices. 2. High initial development and maintenance costs. 3. Limited awareness and adoption among rural or digitally underserved communities.
Opportunities	**Threats**
1. Alignment with national policies and global SDG 9 initiatives promoting digital inclusion. 2. Potential collaboration with disability organizations and local governments. 3. Expansion into smart city integration and public transport systems	1. Dependence on a stable internet connection and high-end mobile devices. 2. High initial development and maintenance costs. 3. Limited awareness and adoption among rural or digitally underserved communities

The SWOT analysis reveals that SahabatInklusi has a strong foundation for innovation, with high potential for policy alignment and multi-sectoral collaboration. Its core strengths lie in its integrated and inclusive design philosophy. However, its success is not guaranteed and critically depends on proactively addressing several key challenges. Primarily, it must navigate the pervasive issue of digital inequality by exploring lightweight app versions or offline functionalities to mitigate weakness W1. Furthermore, ensuring robust cybersecurity and transparent data governance policies is non-negotiable for countering threat T2 and building user trust. Finally, the conceptual advantage of the Pentahelix model must be activated in practice; sustaining cross-sectoral partnerships is essential to overcome the high costs (W2) and technical challenges (W3), while also leveraging the identified opportunities (O1, O2, O3) to fend off competitive threats (T1).

3.3 Inclusive innovation and SDG 9

SahabatInklusi reflects the ongoing paradigm shift in how digital technologies intersect with social inclusion and sustainable development. It moves beyond viewing technology as a mere productivity tool and positions it as a fundamental enabler of human rights and civic participation. According to the UN Flagship Report on Disability and SDGs (2018), digital inclusion is both a human right and an economic imperative. This dual nature is central to the platform's value proposition. The innovation aligns strongly with SDG 9, which emphasizes inclusive infrastructure and sustainable industrialization, but its impact is inherently cross-cutting. By enhancing mobility and access to information, it directly contributes to SDG 10 (Reduced Inequalities). Furthermore, by making public spaces and services more navigable and usable, it actively supports the development of SDG 11 (Sustainable Cities and Communities), demonstrating how a targeted technological intervention can create ripple effects across multiple development goals (Graham & De Sabbata, 2020).

From a theoretical perspective, this conceptual innovation is firmly anchored in Inclusive Design Theory and the Capability Approach. The Inclusive Design framework (Clarkson et al., 2013) promotes usability across diverse ability levels from the outset, ensuring equitable access. SahabatInklusi operationalizes this by building features like voice navigation and sign language translation not as add-ons, but as core, integrated functionalities. Simultaneously, the capability approach by Amartya Sen (1999) provides a profound philosophical foundation. This approach underscores that development should be evaluated based on the expansion of people's "capabilities". Their real freedoms to lead the kind of life they have reason to value. SahabatInklusi embodies this philosophy; it is not about providing a specific service but about empowering users to communicate freely, move independently, and participate safely in society, thereby expanding their universe of achievable life paths (Zheng & Walsham, 2021).

Moreover, this research supports and extends the findings by Thohari (2014) and Poerwanti et al. (2024) that infrastructural and technological accessibility remain major barriers in Indonesian cities. SahabatInklusi does not merely document these barriers but proposes a proactive digital solution that functions as both a technological enabler and a social equalizer. It compensates for inaccessible physical infrastructure in the short term (e.g., by providing navigation that avoids inaccessible routes) while simultaneously collecting data to advocate for long-term physical improvements (e.g., through its reporting feature). In doing so, it transforms digital innovation from a purely technical advancement into a socio-technical movement for inclusion, where technology and social change are co-constructed.

This co-construction is institutionalized through its collaborative framework. By embedding the Pentahelix model within the design process, SahabatInklusi bridges policy, community, and academia to create a sustainable innovation ecosystem. This aligns with Formasi Disabilitas Indonesia (2020), which emphasizes participatory governance and the complementarity between disability rights indicators and SDG metadata. The participatory aspect, driven by the CBD approach, ensures that SahabatInklusi is not just developed for people with disabilities, but with them. This collaborative ethos reflects a crucial shift from a charity-based model of inclusion, which views persons with disabilities as passive recipients of aid, to a rights-based model, which recognizes them as active agents of change with the right to participate in the decisions that affect their lives (Metts, 2004). Thus, the process of building SahabatInklusi is as important as the final product, as it enacts the very principles of inclusion it seeks to promote.

4. Conclusions

The conceptual study of SahabatInklusi demonstrates that inclusive technological innovation, when thoughtfully designed and embedded within a supportive ecosystem, can

serve as a powerful catalyst for profound social transformation. By strategically integrating cutting-edge Artificial Intelligence (AI) and Computer Vision with core universal design principles, SahabatInklusi directly addresses the critical accessibility challenges. Communication, mobility, and safety faced by persons with disabilities in Indonesia. The platform's four integrated feature. The sign language translator, AI-based navigation assistant, accessible facility mapping, and emergency support system are not standalone tools but interconnected components that collectively contribute to the creation of safer, more inclusive, and empowering digital environments. This synergy enables a level of independence and participation that was previously difficult to achieve, proving that technology can be a great equalizer when inclusivity is its foundational blueprint.

This research underscores a critical paradigm for the 21st century: that inclusivity must be embedded not only in physical infrastructure but also, and just as importantly, in the very design of our digital systems and public technologies. The digital realm is now a fundamental part of the public sphere, and access to it is a prerequisite for full citizenship. The proposed implementation framework, leveraging the pentahelix collaboration model and community-based development (CBD) approach, provides a replicable blueprint for encouraging genuine cross-sectoral cooperation between academia, business, government, community, and media. This multi-stakeholder engagement is not optional but essential to ensure the long-term sustainability, relevance, and scalability of such innovations, moving them beyond pilot projects into enduring public goods.

Ultimately, SahabatInklusi aligns with the global vision of the Sustainable Development Goals particularly SDG 9 (industry, innovation, and infrastructure) by fostering equitable innovation and promoting the development of accessible infrastructure, both physical and digital. It also vividly embodies the spirit of SDG 10 (reduced inequalities) and SDG 11 (sustainable cities and communities). This conceptual framework makes a meaningful contribution to the academic discourse on digital inclusion by bridging theoretical models from disability studies, sociotechnical systems, and inclusive design with a practical, implementable solution. More importantly, it provides a solid foundation for future work, including empirical studies to validate its impact, detailed technical development of a functional prototype, and larger-scale pilot deployments in diverse Indonesian cities.

In conclusion, SahabatInklusi represents not merely a technological design but a nascent social movement. It champions a future where technology is harnessed not for marginal efficiency gains but for fundamental human empowerment. It seeks to transform accessibility from an afterthought or a legal compliance issue into a non-negotiable, fundamental human right within Indonesia's ongoing digital transformation, ensuring that no one is left behind in the journey toward a truly inclusive and equitable digital society.

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Author Contribution

Conceptualization, A.H.M., N.A.A.Z., and N.M.R.; Methodology, A.H.M.; Validation, N.A.A.Z.; Formal Analysis, N.M.R.; Investigation, A.H.M., N.A.A.Z., and N.M.R.; Resources, A.H.M., N.A.A.Z., and N.M.R.; Data Curation, A.H.M., N.A.A.Z., and N.M.R.; Writing – Original Draft Preparation, A.H.M.; Writing – Review & Editing, N.M.R.; Visualization, N.A.A.Z.; Supervision, A.H.M.; Project Administration, A.H.M.

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Ethical review and approval were waived for this study because the research exclusively involved the analysis of publicly available literature and policy documents, and did not involve any direct interaction with human subjects or access to identifiable personal data.

Informed Consent Statement

Not available.

Data Availability Statement

This study is a conceptual analysis and no new empirical data were generated. All information and findings are based on the analysis of publicly available literature and policy documents cited in the reference list.

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the author(s) used DeepSeek and Grammarly to assist in refining the language, structure, and clarity of the abstract and in understanding the journal's submission guidelines. After using this tool, the author(s) reviewed and edited the content as needed and took full responsibility for the content of the publication.

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