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BLOCKCHAIN TECHNOLOGY IN ELECTIONS: EXPLORING POTENTIAL AND IMPLICATIONS

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ABSTRACT. *This study aims to explore the potential and implications of implementing blockchain technology in the context of elections and governance. Utilizing a mixed-method approach, including expert interviews, stakeholder surveys, and case studies from various countries, the research provides in-depth insights into how blockchain can revolutionize electoral processes and governance. The findings indicate that blockchain implementation in elections has the potential to enhance the integrity and security of voting processes, though significant challenges exist in terms of existing technological infrastructure and public acceptance. In governance, blockchain offers improvements in transparency and efficiency, yet faces obstacles in scalability, integration with existing IT systems, and data security and privacy. The study also reveals an urgent need for the development of appropriate legal and regulatory frameworks to support blockchain implementation while ensuring data security and privacy. The conclusion emphasizes the importance of a holistic approach and public education in deploying blockchain in the public sector to achieve beneficial and sustainable changes in the digital era. This research contributes significantly to the literature on blockchain, particularly its application in elections and governance, and provides guidance for policymakers and practitioners in effectively integrating this technology.*

Keywords: *Blockchain Technology; Elections; Potential; Implications*

TEKNOLOGI BLOCKCHAIN DALAM PEMILU: EKSPLORASI POTENSI SERTA IMPLIKASINYA

ABSTRAK. Penelitian ini bertujuan untuk mengeksplorasi potensi dan implikasi dari penerapan teknologi blockchain dalam konteks pemilu. Dengan menggunakan metode gabungan kualitatif dan kuantitatif, termasuk wawancara dengan para ahli, survei terhadap pemangku kepentingan, dan studi kasus dari berbagai negara, penelitian ini memberikan wawasan mendalam tentang bagaimana blockchain dapat merevolusi pemilu. Hasil penelitian menunjukkan bahwa penerapan blockchain dalam pemilu berpotensi meningkatkan integritas dan keamanan proses pemungutan suara, meskipun terdapat tantangan signifikan terkait dengan infrastruktur teknologi yang ada dan penerimaan publik. Dalam tata kelola pemerintahan, blockchain menawarkan peningkatan transparansi dan efisiensi, namun dihadapkan pada hambatan dalam hal skalabilitas, integrasi dengan sistem teknologi informasi yang ada, serta keamanan dan privasi data. Studi ini juga mengungkapkan kebutuhan mendesak akan pengembangan kerangka kerja hukum dan regulasi yang sesuai untuk mendukung penerapan blockchain, sambil menjaga keamanan dan privasi data. Kesimpulan penelitian menekankan pentingnya pendekatan holistik dan edukasi publik dalam menerapkan blockchain di sektor publik untuk mencapai perubahan yang bermanfaat dan berkelanjutan dalam era digital. Penelitian ini memberikan kontribusi penting dalam literatur tentang blockchain, khususnya aplikasinya dalam pemilu, dan menawarkan panduan bagi pembuat kebijakan dan praktisi dalam mengintegrasikan teknologi ini secara efektif.

Kata kunci: Teknologi Blockchain; Pemilu; Potensi; Implikasi

INTRODUCTION

In today's digital era, blockchain technology has emerged as one of the most promising innovations, particularly in the election sectors. Recent facts indicate that blockchain, with its transparent and secure nature, offers significant potential to enhance the integrity and efficiency of election processes. This is crucial amidst growing global concerns about election security and transparency in government governance (Elan Maulani et al., 2023; Suryawijaya, 2023). This study aims to explore how blockchain technology can be applied in elections to reduce the risk of fraud, increase voter participation, and ensure the accuracy of election results. Furthermore, this research will also explore the implications of blockchain technology in strengthening good government governance through enhanced transparency and accountability.

This research is critically important given the challenges faced in traditional election processes, such as data manipulation, low public trust, and the potential for fraud that can undermine the legitimacy of election results. By integrating blockchain technology, this study not only offers an innovative solution to enhance transparency and security but also has the potential to rebuild public trust in democratic systems. Furthermore, with the high adoption rate of digital technology across various sectors, the application of blockchain in elections could serve as a new model for more efficient, modern,

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and sustainable governance. This study aims to provide tangible contributions by developing a practical framework for implementing blockchain in election systems while offering insights to policymakers, election organizers, and the wider community about the opportunities and challenges in this digital transformation.

At the time this research was conducted, initial observations highlighted several fundamental challenges in traditional election processes, serving as a critical backdrop for the implementation of blockchain technology. Preliminary analysis revealed significant concerns among stakeholders regarding low public trust in the integrity of election results, stemming from potential data manipulation, weak transparency, and vulnerability to fraud. Additionally, fluctuating voter participation rates underscored the need for innovations that could enhance accessibility and public confidence in the election system. In this context, blockchain implementation is seen as a promising alternative, offering a technology-based solution capable of ensuring transparency, security, and efficiency in election processes. These initial findings form an essential foundation for designing the research framework to further explore the potential and implications of blockchain adoption in electoral governance.

In the aspect of elections, the use of blockchain technology can revolutionize the way votes are collected, counted, and verified, offering solutions to issues such as vote tampering, duplication of votes, and data security problems (Pratama & Kurniadi, 2021). On the other hand, in government governance, blockchain can aid in creating more efficient and transparent systems, where government transactions and decisions can be tracked and audited by the public, thereby increasing accountability (Wibowo, 2019). This research is not only relevant in a theoretical context but also has significant practical implications. Furthermore, the study will identify challenges and barriers in the implementation of blockchain in the public sector, including technical issues, regulatory matters, and public acceptance. An interdisciplinary approach will be used to analyze these aspects, encompassing information technology, law, politics, and sociology.

Blockchain technology, first popularized through its implementation in Bitcoin by Satoshi Nakamoto in 2008, has evolved significantly since its inception. As a record-keeping system that provides a way to store and transfer information in a decentralized and secure manner, blockchain has revolutionized various industry sectors (Guo and Yu 2022; Huynh-The et al. 2023). The key characteristics that distinguish blockchain are its decentralization, where there is no central authority controlling the system; transparency, with every transaction being traceable and verifiable by all users; enhanced security through cryptography; and its immutable nature, meaning that once data is entered, it cannot be altered or deleted.

The implementation of blockchain technology in elections has become a topic of significant interest, particularly due to its potential to enhance integrity and security in the voting process. Research and experiments conducted around the world indicate that blockchain can revolutionize the way elections are conducted. A concrete example of this implementation includes the election experiments in Estonia, which have used this technology for electronic voting, as explained by Tsomaia et al. (2020). Similar experiments have also been conducted in countries like Sierra Leone and Switzerland, offering valuable insights into potential future applications.

The application of blockchain technology in government governance has shown significant potential to enhance operational efficiency, strengthen transparency, and reduce corruption. With its decentralized and transparent structure, blockchain offers a new and more secure way for the recording and management of public data. For example, projects like the land registration system adopted in Georgia, worked on by Pelt et al. (2021), have demonstrated how blockchain can improve reliability and efficiency in public services. Similar implementations have also been done for civil registration and other public services, as outlined by Laatikainen, Li, and Abrahamsson (2023), who explored various use cases of blockchain in public administration.

Efforts have been made around the world to integrate blockchain technology in elections . Some countries have experimented with using blockchain in local or national elections with varying results (Pakpahan & Al-Fahd, 2023). However, these studies are often limited in scale and scope, not fully capturing the full potential of blockchain technology in a broader context. There is a tendency to focus the application of blockchain on its technical aspects only, while legal, political, and social aspects are often overlooked. This creates a gap in a comprehensive understanding of how blockchain can be effectively and sustainably integrated into electoral systems . In the context of government governance, some initiatives have been taken to use blockchain in public administration (Syaban Bashar & Purnamasari, 2022), such as in land registration and other public services. However, challenges in

scalability, interoperability with existing systems, and data security issues remain significant barriers.

This research presents several novel aspects that distinguish it from previous studies on the application of blockchain technology in elections . *Firstly*, the study takes a holistic and multidisciplinary approach in understanding and analyzing blockchain implications. It doesn't just focus on technology and IT aspects but also involves in-depth analysis of legal, political, sociological, and economic aspects related to blockchain implementation. This allows for a more comprehensive evaluation of how this technology can be effectively applied in different contexts. *Secondly*, the research emphasizes empirical studies and practical cases. Apart from existing literature, it will involve case study analysis from countries that have implemented or are experimenting with blockchain in elections or government governance. This approach will provide practical insights into the challenges, successes, and learnings from these efforts. *Thirdly*, the research strives to identify and address gaps in previous research, particularly in terms of scalability, interoperability, and data security in blockchain implementation. Thus, it will contribute to the development of more mature and tested technical solutions to overcome these challenges. *Fourthly*, the study will also explore the potential of blockchain innovations not extensively researched before, such as its use in combating corruption, enhancing public participation in government decision-making processes, and managing public resources. *Lastly*, the findings of this research are expected to make a significant contribution to public policy and government practice. The recommendations generated will provide guidance for policymakers and government practitioners in designing effective and innovative strategies to integrate blockchain technology in elections and governance.

Based on the description above, this research offers numerous beneficial opportunities. Its application in elections requires a mature, well-planned, and multifaceted approach. The recommendations resulting from this study are expected to guide policymakers and practitioners in integrating this technology into public structures, leading to beneficial and sustainable changes in the way governance and elections are conducted in the digital era. This integration aims to enhance transparency, efficiency, and public trust in these critical processes, leveraging the inherent strengths of blockchain technology to address current challenges and set a new standard for public governance and electoral systems in the digital age.

METHOD

This study employs a qualitative approach to deeply understand the implications of blockchain technology in elections (Bager-Charleson & McBeath, 2023; Creswell John and Creswell David, 2023). In collecting primary data, this research involves semi-structured interviews with experts in the fields of blockchain and elections. Respondents were selected based on their expertise and experience to gain an in-depth understanding of their perspectives on blockchain technology. Specifically, this research highlights critical information obtained from an observer, Ady Irawan, who stated that the success of implementing blockchain technology in elections heavily depends on a robust technological infrastructure and supportive regulatory policies. Insights from the observer are specifically cited and analyzed in the Discussion section of the article, enriching the analysis with practical perspectives on the challenges and potential solutions for the use of blockchain in governance.

Additionally, a survey was conducted to collect quantitative data from various stakeholders, namely Dedy Rosadi, Ahmadin, and Junaidin, aiming to assess perceptions and attitudes towards the implementation of blockchain. In this survey, a total of 10 stakeholders were involved, including education practitioners, members of the Election Supervisory Body (Bawaslu), and election officials. Secondary data was obtained from the analysis of existing documents, including government reports, academic publications, and case studies, to provide additional context and validate findings from primary data. Content or thematic analysis techniques were used to process data from interviews, while survey data were processed using descriptive and inferential statistical methods, allowing the analysis of trends and relationships between variables.

This study employs various instruments to ensure the validity and accuracy of the collected data. The primary instruments include closed-ended questionnaires for surveys, semi-structured interview guides for qualitative data collection, and document analysis sheets for reviewing secondary data. The questionnaires are designed to measure perceptions, attitudes, and the potential application of blockchain in elections from the perspectives of different stakeholders. Meanwhile, the interview guides are focused on exploring in-depth information regarding the opportunities and challenges of blockchain implementation, as well as strategic recommendations from qualified informants. These instruments were pre-tested to ensure their reliability and alignment with the research objectives.

The data collection process was conducted in several stages, starting with the distribution of questionnaires to 10 stakeholders, including education practitioners, election officials, and representatives from the Electoral Supervisory Body (Bawaslu). Subsequently, interviews were conducted both in-person and online with selected informants, such as Dedy Rosadi, Ahmadin, and Junaidin, to gain deeper insights. Data analysis was carried out using thematic analysis techniques for qualitative data and descriptive and inferential statistical methods for quantitative data. Statistical analysis enabled the researchers to identify patterns and relationships between variables, while thematic analysis helped organize key categories and themes relevant to the application of blockchain in elections. This combination of analysis techniques provides a comprehensive understanding of the potential and implications of blockchain technology in enhancing the integrity and efficiency of the electoral process.

This research emphasizes validity and reliability through data triangulation, ensuring consistency and accuracy of findings by cross-verifying results from various sources and methods. Research ethics were strictly maintained through informed consent from respondents, ensuring confidentiality and anonymity of data, and preserving objectivity during data collection and analysis. By employing this method, the research aims to present a comprehensive and in-depth view of the application of blockchain in the context of elections, ensuring findings and recommendations are informative, relevant, and reliable

RESULT AND DISCUSSION

Based on the research methods outlined, this discussion will analyze findings from research on the use of blockchain technology in elections, focusing on its implications.

Application of Blockchain in Elections

The data analysis indicates that the use of blockchain in elections has significant potential to enhance the integrity and efficiency of the voting process. Interviews with experts revealed that blockchain can reduce the risk of election fraud and increase public trust in the election results. However, survey results indicate concerns among voters regarding their understanding of this technology and data security. Case studies from countries that have implemented blockchain in elections, such as Estonia and Sierra Leone, provide empirical evidence of the effectiveness and challenges of this technology's implementation. From these case studies, it becomes clear that the success of blockchain application in elections heavily depends on the existing technological infrastructure and public awareness of blockchain technology.

According to the research by Baothman et al. (2021)secure, and immutable platforms. Its first appearance is connected with monetary cryptocurrency transactions, followed by adaptation in several domains. We believe that blockchain can provide a reliable environment by utilizing its unique characteristics to offer a more secure, costless, and robust mechanism suitable for a voting application. Although the technology has captured the interest of governments worldwide, blockchain as a service is still limited due to lack of application development experience, technology complexity, and absence of standardized design, architecture, and best practices. Therefore, this study aims to build an imperial example for a blockchain electronic voting (e-voting, the implementation of blockchain in elections can effectively prevent vote manipulation and provide a stronger verification system. This has the potential to transform the way voting is conducted, by reducing the risk of fraud and enhancing public trust in the electoral process. The concerns related to understanding and data security revealed from the survey results indicate significant obstacles in public acceptance and adoption of this technology. This aligns with the findings of Cooley, Wolf, and Borowczak (2019), who emphasize the importance of education and public outreach to enhance understanding of blockchain. This awareness is crucial to address doubts and enhance trust in the implementation of this technology in elections.

The case study from Indonesia demonstrates that the use of blockchain in e-voting systems has improved the efficiency and security of elections. Research by Esgin et al. (2023)we study the blockchain leader election problem. The purpose of such protocols is to elect a leader who decides on the next block to be appended to the blockchain, for each block proposal round. Solutions to this problem are vital for the security of blockchain systems. We introduce an efficient blockchain leader election method with security based solely on standard assumptions for cryptographic hash functions (rather than public-key cryptographic assumptions reveals that the implementation of this technology has been positively received, showing an increase in voter participation and trust in the electoral system.

Meanwhile, the case study from Sierra Leone, as described by Wisessing et al. (2020), highlights the challenges faced in implementing blockchain in a country with less developed technological infrastructure. This indicates that the success of blockchain implementation in elections depends not only on the technology itself but also on the infrastructural and socio-economic context in which it is applied.

The findings of this study also indicate that implementing blockchain in elections requires a strategic approach that considers the readiness of technological infrastructure, regulations, and government policy support. Additionally, public engagement through education and outreach about how blockchain works becomes a crucial element in enhancing public acceptance of this technology. Collaboration between election organizers, technology providers, and local communities can accelerate blockchain adoption in electoral systems in a more inclusive and sustainable manner. Therefore, the success of blockchain implementation is not only determined by the technology's capabilities but also by strengthening the overall electoral ecosystem, including technical training for election organizers and providing adequate budgets to build the necessary infrastructure. With this strategy, blockchain can act as a catalyst in realizing an election system that is more transparent, secure, and trusted by the public.

More broadly, blockchain plays a significant role in strengthening the global democratic goals by enhancing transparency, accountability, and public trust in electoral systems. By reducing the potential for vote manipulation and improving accessibility and security, this technology contributes to better governance reforms worldwide. In the context of global electoral challenges, such as distrust in election results and data insecurity, blockchain offers a fundamental solution to improve the process and provide greater confidence in the integrity of elections. The application of blockchain, with its decentralization and transparency characteristics, can support more open, fair, and efficient governance, having a positive impact on democratic systems in various countries.

In conclusion, the implementation of blockchain in elections shows tremendous potential for enhancing democracy and electoral governance. However, to realize this potential, there is an urgent need to overcome technical, social, and educational barriers. Public education, the development of appropriate infrastructure, and supportive regulation are key aspects that will determine the success of blockchain implementation in future electoral systems.

Blockchain in Governance

Research findings indicate that blockchain has significant potential in enhancing transparency and accountability in government governance. Data from interviews with government officials and document analysis show that blockchain can be used to optimize public administration processes, such as land registration and civil data management. However, there are significant challenges in its implementation, including issues of scalability and integration with existing information technology systems. Survey results also indicate a need for further public education to ensure broader acceptance of the implementation of this technology.

Further analysis of the research findings suggests that the implementation of blockchain in government governance can not only improve transparency and accountability but also facilitate more efficient and open policy processes. For example, the use of blockchain in land registration, as seen in the case study of Georgia, has brought significant changes in reducing processing time and enhancing public trust in the legitimacy and security of land transactions. Research by Pelt et al. (2021) indicates that this can contribute to improving the investment climate and economy.

Furthermore, this study found that blockchain can be utilized to enhance government budget management by ensuring transparency in the allocation and use of public funds. The implementation of blockchain technology in government budget oversight has proven effective in reducing the risk of corruption and improving the efficiency of public financial management. This technology enables real-time tracking of financial transactions, allowing every flow of funds to be monitored by both the public and relevant authorities. These findings underscore that the application of blockchain in governance not only strengthens transparency and accountability but also provides a foundation for more effective and trustworthy financial management.

However, the challenges in implementing blockchain in government governance primarily revolve around issues of scalability and integration with existing information technology systems. For example, Laatikainen, Li, and Abrahamsson (2023) highlight how the technological differences between legacy systems and blockchain can create difficulties in fully adopting this technology. Additionally, other challenges faced include data security and privacy concerns that arise when managing public and sensitive data through blockchain. This requires a balance between

transparency and the protection of personal data, as discussed by Tan, Mahula, and Crompvoets (2022).

The survey results indicate a need for further public education to ensure broader acceptance of this technology's implementation. Research by (Fischer and Valiente (2021) underscores the importance of providing easily accessible and understandable information to the public about how blockchain works and the benefits it offers, in order to build public trust and engagement.

In conclusion, while blockchain offers significant potential for transforming government governance, there are barriers that need to be overcome, including technical issues, the need for appropriate legal and regulatory frameworks, as well as increasing public understanding and acceptance. This research emphasizes the importance of a holistic approach in adopting blockchain, which involves not only technical improvements but also social, legal, and political considerations.

Laws and Regulations

The analysis finds that current laws and regulations are not yet fully prepared to accommodate the implementation of blockchain in elections. Interviews with legal and regulatory experts emphasize the need for a clearer legal framework that supports blockchain technology, while maintaining data security and privacy. There is also a need to develop stronger security standards and protocols to protect the data generated and managed through blockchain.

In addition to challenges in developing a supporting legal framework, further analysis also indicates a need to align existing regulations with the dynamics of blockchain technology. This involves reviewing and updating regulations related to digital data, electronic transactions, and cybersecurity to ensure that blockchain can be effectively integrated into the existing legal system. Njogu (2021) highlights that rigid and inflexible regulations can hinder innovation and the full utilization of blockchain's potential.

Furthermore, the findings of this study indicate that collaboration among policymakers, election organizers, and technology experts is essential to ensure that the regulations formulated are not only responsive to the needs of blockchain technology but also inclusive and oriented toward protecting citizens' rights. This approach involves public consultations and stakeholder participation to ensure that the resulting regulations reflect the needs and aspirations of the broader community. A collaborative approach to drafting technology regulations can accelerate blockchain adoption while minimizing legal and operational risks. Therefore, the development of an adaptive and innovative legal framework becomes a strategic step to support the successful implementation of blockchain in elections and other government sectors.

It's also crucial to consider the cross-jurisdictional aspects of blockchain, especially in the context of elections involving cross-border data and transactions. Research by Reeves and O'grady (2022) indicates that international cooperation and regulatory harmonization can be key aspects in supporting the global implementation of blockchain.

Furthermore, interviews with experts reveal concerns about the potential misuse of blockchain technology if not properly regulated. This reinforces the argument for developing oversight and accountability mechanisms in the use of blockchain in the public sector. Savirimuthu (2019) emphasizes the importance of developing systems that not only leverage the transparency offered by blockchain but also protect individual rights and privacy.

In the context of elections, regulations must ensure that blockchain technology is used to enhance the fairness and integrity of the voting process, without sacrificing voter rights and democratic principles. Case studies from countries that have implemented blockchain in elections reveal that a strong and adaptive regulatory framework is key to maintaining public trust and electoral integrity.

In conclusion, this research indicates an urgent need to revise and adapt the legal and regulatory frameworks supporting the implementation of blockchain in elections. This encompasses the development of security standards, privacy protocols, as well as regulations that support innovation while protecting public interests.

Social Impact and Public Acceptance

Survey and interview findings indicate a divide in public acceptance of blockchain. While many welcome its potential for transparency and efficiency, there remain concerns about the technology's complexity and its impact on data privacy. Research also shows that well-managed blockchain implementation can have significant social impacts, including increased public participation and trust in governance.

Beyond initial findings, further analysis reveals that introducing blockchain in the public sector requires an effective communication strategy to address misunderstandings and knowledge barriers. For instance, a study by Giri and Manohar

(2023) highlights the importance of targeted educational and awareness campaigns to enhance public understanding of the advantages and risks of blockchain technology. This could include initiatives such as workshops, seminars, and easily accessible educational materials for the general public.

Furthermore, this study found that the success of blockchain implementation in the public sector is highly influenced by the level of digital literacy within the community. The survey revealed that groups with higher digital literacy are more open to adopting blockchain compared to those less familiar with the technology. Digital literacy is a key factor in determining the level of public acceptance of new technologies. Therefore, blockchain implementation strategies should include comprehensive digital literacy programs to enhance community readiness, ensure inclusive technology adoption, and minimize resistance to change. With this approach, blockchain can not only be widely accepted but also leveraged to create more positive social impacts.

Furthermore, the social impact of blockchain implementation is closely linked to how this technology affects interactions between citizens and the government. Research by Cagigas et al. (2022) suggests that the use of blockchain can open new opportunities for citizen participation in government decision-making processes, such as through more transparent and accessible e-voting or e-governance platforms. However, this also raises questions about ensuring inclusivity, particularly for groups with limited technological literacy or restricted access to digital resources.

Additionally, the analysis finds that public acceptance of blockchain also depends on how this technology addresses their needs and concerns regarding privacy and data security. As explained by Hong et al. (2021), there is a need to develop and implement blockchain solutions that are not only efficient but also adhere to strict data privacy and security standards.

In conclusion, the findings indicate that the implementation of blockchain in elections has the potential for significant social impact, but its success heavily depends on how challenges in public acceptance, privacy, and data security are addressed. An inclusive, transparent approach focused on public education will be crucial in ensuring that the benefits of blockchain technology can be enjoyed by all segments of society.

CONCLUSION

This research, exploring the use of blockchain technology in elections, reveals significant potential as well as a series of challenges that must be addressed. From data analysis, interviews with experts, and case studies, it was found that blockchain has the capacity to enhance integrity, security, and transparency in elections, while offering improved efficiency in government governance. However, the success of its implementation heavily depends on the available technological infrastructure as well as the level of public understanding and acceptance. Other major challenges include the development of appropriate legal and regulatory frameworks that can support innovation while protecting privacy and data security. This study also highlights public division in accepting blockchain, underscoring the importance of education and effective communication strategies to increase public awareness. The conclusions from this research emphasize the need for a holistic approach in adopting blockchain, combining technical, social, legal, and political considerations, to ensure the successful, transparent, and efficient integration of this technology in elections.

In addition, this study highlights the importance of collaboration among various stakeholders, including governments, election organizers, academics, and the private sector, to build an ecosystem that supports blockchain adoption. Such collaboration is essential to ensure that every aspect of blockchain implementation, from system design to operational management, meets the standards of security, efficiency, and inclusivity. This study also recommends strategic measures such as enhancing public digital literacy, developing adequate technological infrastructure, and improving the capacity of human resources involved in managing blockchain systems. With well-planned and integrated strategies, blockchain can serve as a catalyst for broader reforms in governance, particularly in creating fairer, more transparent, and trustworthy electoral systems. Further research is needed to explore the deeper social, economic, and political dynamics related to the implementation of this technology in various national contexts.

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