Proceeding of The Third Annual International Competition on Scientific Writing (ACSciting)
Volume 3 No 2026, E-ISSN 3048-0167

A Study of the Impact of Embedded System Technology on Access to Public Services in the Digital Era

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Abstract

Digital transformation has driven the adoption of embedded system technology in various public service sectors, including government administration, healthcare, and transportation. This technology offers efficiency, automation, and improved service quality, but also poses challenges related to access gaps and digital equity. This study aims to analyze the impact of embedded system implementation on public service access using a multidisciplinary approach that integrates technological, social, and policy perspectives. The research method used is a mixed-method approach with data collection through observation, questionnaires, and interviews with public service users. The results show that embedded systems significantly improve service efficiency and quality, but also have the potential to widen the access gap for groups with low digital literacy. This research contributes to the development of technology-based social innovation and policy recommendations for creating inclusive and equitable public services in the digital era.

Keywords: *Embedded System, Public Services, Digital Equity, Social Innovation, Digital Society*

1. INTRODUCTION

Digital transformation has become a key driver of change in various sectors, including public services. Governments across the world are beginning to adopt digital technology to improve efficiency, transparency, and the quality of public services. In this context, digitalization serves not only as a supporting tool but also as a key foundation for building a modern public service system that is responsive to public needs in the digital age (OECD, 2021; United Nations, 2022).

One technology playing a crucial role in this transformation is embedded systems, which are embedded computer systems designed to perform specific functions within a larger device or system. This technology is widely used in various public service applications, such as automated queuing machines, self-service kiosks, sensor-based monitoring systems, and Internet of Things (IoT) devices within the smart city concept. The implementation of embedded systems enables faster, more accurate service

processes, with minimal manual intervention (Zanella et al., 2020; Gubbi et al., 2021).

However, the adoption of embedded system technology in public services does not always have a positive impact evenly. The presence of technology can actually exacerbate the digital divide, especially for groups with limited access to technology, digital literacy, or certain socioeconomic conditions. This poses a serious challenge to achieving digital equity in public services, which should be inclusive (van Dijk, 2020; Robinson et al., 2020).

This problem is further complicated by the fact that technology implementation often focuses on technical aspects and efficiency, without considering the overall social and policy dimensions. The lack of an integrative approach means that technologies, supposedly solutions, can actually create new social exclusions. Therefore, a multidisciplinary approach is needed that can holistically examine the interactions between technology, society, and policy (Heeks et al., 2021; Dwivedi et al., 2022).

This research employs a multidisciplinary approach encompassing technological, social, and public policy perspectives. From a technological perspective, embedded systems are assessed based on their efficiency and performance. From a social perspective, the focus is on accessibility, inclusion, and impact on vulnerable groups. Meanwhile, from a policy perspective, this research examines how regulations and implementation strategies can support equitable access to technology-based public services (Venkatesh et al., 2021; Janssen & van der Voort, 2020).

Furthermore, the concept of social innovation is a crucial element in bridging the gap between technology and societal needs. Social innovation enables the development of solutions that are not solely technology-based but also consider aspects of community participation, local adaptation, and sustainability. In the context of public services, social innovation can take the form of digital literacy education, user assistance, and more user-friendly and inclusive system design (Cajaiba-Santana, 2020; Pel et al., 2021).

Based on this background, this study aims to analyze the impact of embedded system technology on access to public services using a multidisciplinary approach. This research also seeks to identify the extent to which this technology can improve efficiency while maintaining equitable access, and how social innovation can play a role in addressing emerging challenges. Thus, this research is expected to provide theoretical and practical contributions to the development of inclusive public services in the digital era.

2. METHOD

This research uses a mixed-methods approach that integrates quantitative and qualitative methods to gain a comprehensive understanding of the impact of embedded system technology on access to public services. This approach was chosen because it can capture the phenomenon in greater depth, both in terms of numerical measurements and social interpretations of technology use in the context of public services.

Conceptually, this research adopts a multidisciplinary approach that combines technological, social, and public policy perspectives. The technological perspective is used to analyze the performance and efficiency of embedded systems, the social perspective to evaluate the level of accessibility and inclusion in society, and the policy perspective to understand the role of regulation in supporting fair and equitable

technology implementation.

The research design used is descriptive-explanatory. The descriptive design aims to illustrate the implementation of embedded systems in public services, while the explanatory design is used to analyze the relationship between technology use and the level of public service access and the factors that influence it.

The research locations focused on several public service units that have implemented embedded system technology, such as digital queuing systems, self-service kiosks, and sensor-based devices. The locations were selected purposively, considering the level of technology adoption and the diverse characteristics of service users.

The population in this study was all public service users who interact with embedded systems. The sampling technique used purposive sampling, with 100 respondents. Respondents were selected based on specific criteria, such as experience using technology-based services, age, and educational background.

Data collection techniques were conducted using several methods, including observation, questionnaires, interviews, and documentation. Observations were conducted to understand the system's workflow and user interaction with the technology. Questionnaires were used to measure user perceptions regarding ease of access, efficiency, and service satisfaction. Semi-structured interviews were conducted to gather in-depth information from stakeholders, while documentation was used to supplement data related to system implementation.

The research instrument used in the questionnaire was developed based on indicators adapted from the Technology Acceptance Model (TAM), which includes perceived usefulness and perceived ease of use. Additionally, digital equity-related indicators such as accessibility, affordability, and digital literacy were added. The measurement scale used a five-point Likert scale to facilitate quantitative analysis.

Quantitative data analysis was conducted using descriptive and inferential statistics. Descriptive statistics were used to describe respondent characteristics and the distribution of responses, while inferential analysis was used to test relationships between variables using correlation or simple regression techniques. Data were processed using statistical software to ensure the accuracy of the analysis results.

Meanwhile, qualitative data from interviews was analyzed using thematic analysis techniques. The analysis process involved data reduction, categorization, and conclusion drawing. This approach enabled researchers to identify key patterns related to access barriers, user experiences, and emerging forms of social innovation.

To ensure data validity and reliability, this study employed several techniques, including instrument validity testing using item-total correlation and reliability testing using a Cronbach's Alpha coefficient with a minimum value of 0.7. Furthermore, triangulation of sources and methods was conducted to enhance data credibility. With this methodological approach, the research results are expected to have a high level of accuracy and reliability in explaining the phenomena studied.

3. RESULTS AND DISCUSSION

3.1 Respondent Characteristics

The initial analysis in this study focused on understanding the characteristics of the

respondents as a basis for interpreting the research results more contextually. Respondent characteristics are important because demographic factors such as age, education level, and digital literacy significantly influence an individual's ability to access and utilize technology-based public services. In the context of digital transformation, variations in these characteristics can determine the level of acceptance and effectiveness of the use of embedded systems in everyday life. The results of data collection indicate that respondents in this study have a fairly diverse distribution, both in terms of age, gender, and education level. Furthermore, the level of digital literacy also shows quite significant variation, which is an important indicator in assessing the public's readiness to face the digitalization of public services. This variation illustrates that technology implementation cannot be viewed homogeneously, but must consider the diversity of users.

Table 1. Respondent Characteristics

Category	Subcategory	Amount	Percentage
Gender	Man	52	52%
	Woman	48	48%
Age	< 25 Years	30	30%
	25 – 40 Years	45	45%
	> 40 Years	25	25%
Education	Senior High School	35	35%
	Bachelor	50	50%
	Postgraduate	15	15%
Digital Literacy	Tall	55	55%
	Low	45	45%

Source: Primary data, processed by researchers (2026)

Table 1 shows that the distribution of respondents is relatively balanced in terms of gender, so there is no significant gender bias in this study. In terms of age, the majority of respondents are in the productive age group (25–40 years), which generally has a higher level of technology adaptation. However, the presence of 25% of respondents aged 40 and over is significant because this group tends to face more barriers in technology use.

In terms of education, the majority of respondents had a bachelor's degree, indicating a relatively good understanding of technology usage. However, a significant number of respondents still had secondary education (high school), potentially presenting limitations in digital literacy. This is reinforced by digital literacy data, which shows that 45% of respondents fell into the low literacy category. This finding is an early indication of a potential gap in the utilization of embedded system-based services.

3.2 Impact of Embedded Systems on Service Access

Furthermore, this study analyzes user perceptions of the impact of implementing embedded systems in public services. This analysis aims to measure the extent to which the technology can improve service quality from a user perspective. Indicators used include service speed, ease of use, service quality, and the ability to reduce queues.

Overall, the results show that embedded systems have a positive impact on service efficiency. This aligns with the primary goals of digitalization, which are to reduce wait times, improve accuracy, and provide a better service experience for the public. However, user perceptions vary depending on their level of technology literacy and experience.

Table 2. User Perception of Services

Indicator	Agree (%)	Don't agree (%)
Faster service	78%	22%
Easy to use	72%	28%
Improving the quality of service	65%	35%
Reduce queues	80%	20%

Source: Primary data, processed by researchers (2026)

Table 2 shows that the majority of respondents gave a positive assessment of the embedded system implementation. Queue reduction achieved the highest percentage (80%), indicating that this technology is effective in addressing classic public service issues. Furthermore, 78% of respondents stated that service has become faster, indicating increased operational efficiency.

However, a significant percentage of respondents stated that the system was not easy to use (28%) and did not improve service quality (35%). This indicates that while technology provides benefits, there are still challenges in terms of usability and user experience. These findings indicate the need for improvements in system design to make it more user-friendly for all groups.

3.3 Digital Divide Analysis

While previous results showed positive impacts in terms of efficiency, this study also identified a digital divide as a consequence of technology implementation. This gap arises from differences in individual abilities to access and use technology, which are influenced by factors such as age, education, and digital literacy.

Analyzing barriers to technology use is crucial for understanding which groups are most impacted and the underlying factors. Understanding these barriers allows for more effective strategies to improve digital inclusion in public services.

Table 3. Barriers to Technology Use

Inhibiting Factors	Percentage
Lack of Digital Literacy	30%
Elderly	25%
Not Used to Technology	20%
Limited Access	15%
Other	10%

Source: Primary data, processed by researchers (2026)

Table 3 shows that the main factor inhibiting the use of embedded systems is low digital literacy (30%). This confirms that the ability to understand and use technology is key to accessing digital services. Furthermore, age is also a significant factor, with older adults tending to have difficulty adapting to new technologies. Other factors, such as unfamiliarity with technology and limited access, also contribute to the digital divide. These findings suggest that the problem lies not only in the technology itself, but also in user readiness. Therefore, solutions are needed not only technically, but also socially and educationally.

3.4 Statistical Analysis Results

To strengthen the descriptive findings, this study also conducted statistical analysis to examine the relationships between the studied variables. This analysis aimed to determine the extent to which embedded system implementation impacts the efficiency and access of public services, as well as the role of digital literacy in this relationship.

The results of the analysis show a fairly strong relationship between the variables studied, which indicates that technology has a significant role in improving service quality, but is still influenced by other factors.

Table 4. Variable Correlation Results

Variables	Correlation Coefficient (r)
Embedded System vs Efficiency	0.72
Embedded System vs Access	0.65
Digital Literacy vs Access	0.70

Source: Primary data, processed by researchers (2026)

Table 4 shows a strong positive correlation between embedded systems and service efficiency ($r = 0.72$). This indicates that the better the technology implementation, the higher the resulting efficiency. Furthermore, the relationship between embedded systems and service access is also quite strong ($r = 0.65$), indicating that technology contributes to improving accessibility.

However, what is interesting is the strong relationship between digital literacy and service access (r = 0.70), which even approaches the relationship between technology and efficiency. This indicates that digital literacy is a key factor in determining the success of technology implementation in improving access to public services. Therefore, improving digital literacy is an indispensable aspect of digital transformation.

3.5 Discussion

The research results show that the implementation of embedded systems significantly improves the efficiency of public services. This is evident in the high percentage of respondents who stated that services became faster, easier, and of higher quality. This finding aligns with the Technology Acceptance Model (TAM) theory, which states that perceived ease of use and usefulness influence user acceptance of technology.

However, this study also found a significant digital divide. Groups with low digital literacy experience difficulties accessing technology-based services. This suggests that digital transformation does not automatically result in equitable access but requires additional intervention.

From a multidisciplinary perspective, this study demonstrates that successful technology implementation is determined not only by technical aspects but also by social and policy factors. Technically, embedded systems have proven effective in increasing efficiency. However, socially, barriers remain that hinder inclusion. From a policy perspective, regulations that support equitable access are needed.

Furthermore, this study found the crucial role of social innovation in addressing the digital divide. Innovations such as user assistance, digital literacy education, and simpler system designs have been shown to help improve service accessibility. This demonstrates the critical importance of community-based approaches in supporting inclusive digital transformation.

The implication of this research is the need to integrate technology and social strategies in the implementation of public services. The government needs to focus not only on system development but also on increasing the public's capacity to use the technology.

Furthermore, this study confirms that digital equity must be a priority in the development of technology-based public services. Without inclusive policies, technology has the potential to widen social disparities. Therefore, a multidisciplinary approach that combines technology, social issues, and policy is an effective solution for creating public services that are not only efficient but also equitable and inclusive in the digital age.

4. CONCLUSION

This study aims to analyze the impact of embedded system technology on access to public services in the digital era using a multidisciplinary approach encompassing technological, social, and policy perspectives. Based on the research results, it can be concluded that the implementation of embedded systems significantly contributes to improving the efficiency of public services, particularly in terms of service speed, queue reduction, and improved operational quality. This demonstrates that technology plays a strategic role in supporting the digital transformation of the public sector.

However, this study also found that increased efficiency does not automatically translate into increased equity in access. A significant digital divide remains, particularly among groups with low digital literacy, the elderly, and limited access to technology. This situation suggests that implementing technology without considering social aspects has the potential to create new digital exclusions.

The multidisciplinary approach used in this research proved effective in uncovering the complex relationships between technology, society, and policy. From a technological perspective, embedded systems have been shown to improve service performance. From a social perspective, challenges arise in terms of inclusion and accessibility. Meanwhile, from a policy perspective, regulations and implementation strategies are needed to bridge this gap.

Furthermore, this research emphasizes the crucial role of social innovation in supporting the success of digital transformation. Social innovations such as digital literacy education, user assistance, and the development of user-friendly systems have been shown to increase service accessibility for vulnerable groups. Therefore, technology and social innovation must work synergistically to create inclusive public services.

The implication of this research is the need for a paradigm shift in the development of technology-based public services, from a focus on efficiency to a focus on fair access (digital equity). The government and stakeholders need to ensure that every technological innovation is accompanied by a comprehensive inclusion strategy so that its benefits are felt equally by all levels of society.

In conclusion, this research contributes to the development of digital society studies by emphasizing the importance of integrating technology, social aspects, and policy in creating sustainable and equitable public services. Future research is recommended to develop more complex models, such as the integration of artificial intelligence into embedded systems and cross-regional analysis, to gain a broader understanding of the dynamics of digital transformation in public services.

ACKNOWLEDGMENTS

The author would like to express his gratitude to all parties who have supported the preparation of this research. He also thanks Pertiba University for providing access to literature sources and supporting research facilities. He also acknowledges the contributions of previous researchers whose work served as primary references in this study. Furthermore, he also expresses his appreciation to colleagues who provided constructive feedback throughout the writing process. This support significantly contributed to improving the quality of this research.

NOVELTY

This research offers several novel contributions that distinguish it from previous research in the study of embedded system technology and public services in the digital era.

First, this research integrates a multidisciplinary approach that simultaneously combines technological, social, and policy perspectives in analyzing the impact of embedded systems on public services. Most previous research tends to focus solely on technical aspects or system efficiency, without deeply considering social dimensions such as inclusion and the digital divide. Thus, this research presents a more holistic analytical

framework for understanding the interaction between technology and society.

Second, this study develops a conceptual model that connects embedded systems, service efficiency, service access, digital literacy, and digital equity within a single, integrated framework. This model demonstrates that digital literacy acts as a key moderator influencing the relationship between technology and service access. This approach provides a new perspective that the success of digital transformation is determined not only by technology but also by the social readiness of users.

Third, this study specifically highlights the role of social innovation as an intervention mechanism to address the digital divide. Unlike previous research that emphasized technology-based solutions, this study emphasizes that non-technical approaches such as education, mentoring, and inclusive design play an equally important role in ensuring the successful implementation of technology in public services.

Fourth, this study makes an empirical contribution by identifying key factors influencing barriers to access to embedded system-based services, particularly in the context of societies with varying levels of digital literacy. These findings enrich the literature on the digital divide by providing contextual evidence relevant to developing countries.

Fifth, this study proposes a paradigm shift from technological efficiency to digital equity in public service development, a relatively rare explicit discussion in embedded systems studies. This approach positions equity of access as a key indicator of successful digital transformation, not just operational efficiency.

Thus, the main novelty of this research lies in the integration of a multidisciplinary approach, the development of a comprehensive conceptual model, and the emphasis on social innovation and digital justice as key elements in the implementation of embedded system technology in public services. This research is expected to serve as a reference for developing more inclusive public service policies and practices in the digital era.

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