Advance Sustainable Science, Engineering and Technology (ASSET)
Vol. 8, No.2, April 2026, pp. 02602016-01 ~ 02602016-020
ISSN: 2715-4211 DOI: https://doi.org/10.26877/asset.v8i2.2517

EAZY Digital Accreditation System Evaluation and its Contribution to Digital Citizen: Evidence from POLTESA

Runik Machfiroh[1*], Akhmad Fauzi[2], Yusza Reditya Murti[2], Hasbi Syuhada[3]

[1]School of Creative Industry, Telkom University, Jl. Telekomunikasi No. 1, Terusan Buahbatu, Bojongsoang, Bandung, West Java, 40257, Indonesia

[2]School of Economics and Business, Telkom University, Jl. Telekomunikasi No. 1, Terusan Buahbatu, Bojongsoang, Bandung, West Java, 40257, Indonesia

[3]Telkom Indonesia, Telkom Landmark Tower, Jl. Jenderal Gatot Subroto Kav. 52, Kuningan Barat, Jakarta Selatan, Jakarta, 12710, Indonesia

*runikmachfiroh@telkomuniversity.ac.id

Abstract. Accreditation processes in higher education institutions are often inefficient, particularly in border regions like Indonesia, where limited infrastructure and resources pose significant challenges. This study evaluates the EAZY Digital Accreditation System at POLTESA, a State Polytechnic in West Kalimantan one of border region of Indonesia. using a mixed-methods approach and Social Return on Investment (SROI) analysis to assess its operational and social impacts. The research combines qualitative stakeholder surveys with quantitative SROI metrics to measure efficiency gains and cost savings. Key findings reveal an SROI ratio of 3.948:1 in Year 1, increasing to 11.1:1 by Year 3, along with IDR 592 million in savings. The results highlight the system's success in improving accreditation efficiency, offering valuable lessons in digital transformation. Furthermore, the implementation of the digital accreditation system enhances digital citizenship by fostering greater transparency, accountability, and participatory governance in educational institutions. These findings suggest that digital accreditation systems can be scaled to other institutions, bridging gaps in educational quality and supporting national resilience.

Keywords: digital accreditation system evaluation, digital citizenship, EAZY, efficiency, SROI

(Received 2025-08-07, Revised 2026-02-20, Accepted 2026-01-29, Available Online by 2026-03-31)

1. Introduction

Accreditation is a fundamental process in higher education, ensuring that institutions adhere to established academic and operational standards. However, in many remote and border-region institutions, the accreditation process often faces significant barriers [1]. These challenges stem from infrastructural limitations, insufficient access to technology, and lack of trained personnel, which lead to inefficiencies such as delayed accreditation timelines, increased costs, and a lack of transparency in evaluating academic standards [2]. As many institutions in disadvantaged regions struggle to meet the technological and administrative demands of accreditation systems, the critical question arises: How can digital tools help bridge the performance gaps in remote institutions and improve accreditation processes to deliver measurable value?

The potential for digital transformation in education, particularly in the field of accreditation, has been explored through various technological innovations. Blockchain technology, for instance, has been proposed to address the challenges of academic certificate verification, ensuring that academic credentials are authentic, secure, and easily verifiable. Effiong demonstrates how blockchain offers a transparent and tamper-proof system that enhances trust in the accreditation process [2]. Hussain discusses the Cerberus blockchain-based system, which aims to simplify the verification of academic credentials and accreditation, potentially reducing fraud and increasing the trustworthiness of the entire system [3]. Similarly, Dunne highlight blockchain's role in improving validation and authentication in the academic world, proposing blockchain-based solutions that support digital certificates and institutional accreditation systems [4].

While blockchain is a promising tool, the adoption of digital tools in remote and resource-constrained regions remains a major hurdle. Aguilar-Alonso emphasizes the importance of using impact evaluations for education systems, noting that, although digital tools can streamline administrative tasks, their effectiveness depends on the readiness of the institutional infrastructure and the digital skills of faculty and staff [5]. In remote regions, where such infrastructures are often absent or underdeveloped, the performance gaps in digital adoption become apparent. Lin further illustrates how digital systems, such as digital competency evaluation frameworks, can improve the effectiveness of accreditation systems, but their success largely depends on institutional readiness, which may be lacking in remote areas. Therefore, a digital divide exists that undermines the equitable adoption of such technologies in these regions [1].

Furthermore, beyond the operational efficiency and cost-effectiveness that digital solutions provide, there is a pressing need to evaluate the social impact of these technologies, especially in marginalized or underrepresented regions. Tariq argues that digital transformation, while improving operational efficiency, must also contribute to social value by enhancing access to education, empowering communities, and fostering inclusive development [6]. Mihai and Hao discuss how Social Return on Investment (SROI) has been used to measure the broader societal impacts of investments in various sectors, including education [7], [8]. SROI goes beyond traditional financial returns to evaluate the social impact, which includes community engagement, economic benefits, and social equity. By incorporating SROI into the evaluation of digital accreditation systems, we can assess not only their economic efficiency but also their social benefits, such as increased educational opportunities and improved institutional transparency [9].

In this context, the application of SROI analysis to digital accreditation systems in remote regions is particularly valuable. It provides a comprehensive framework to assess both financial returns and social value, which has been largely overlooked in previous research. Hemairy and Ghani emphasize that assessing the social impacts of digital tools is essential to understand their full potential, particularly in contexts where traditional metrics like cost and efficiency are insufficient to capture the broader societal benefits [10], [11]. Bansode and Lee underscore the importance of integrating advanced technologies like digital twins, which simulate and optimize systems for enhanced decision-making in accreditation processes. These technologies can offer valuable insights into the performance of digital systems and their potential to drive social and economic change [12], [13].

While blockchain-based tools and digital competency frameworks promise to revolutionize accreditation, their successful deployment in remote regions requires a nuanced approach. Basset highlights the potential of autonomous assessment systems, which can reduce human error and streamline the accreditation process in fields like engineering and technical education [14]. However, these systems require robust infrastructure and skilled personnel to manage them effectively, both of which are often lacking in border-region institutions. Granger and Giorbelidze stress the importance of digital leadership and citizenship to ensure the effective adoption and sustainability of digital tools [15], [16]. In particular, digital citizenship education is crucial for preparing faculty and students to effectively engage with digital platforms, ensuring that these systems are used to their full potential [17].

The objective of this study is to evaluate the effectiveness of digital accreditation systems, particularly the EAZY Digital Accreditation System, in remote institutions. Specifically, this research will assess how digital systems can improve accreditation efficiency, reduce costs, and ensure institutional transparency [18]. In addition to evaluating operational metrics, this study will also apply SROI analysis to measure the social value created by the digital transformation of accreditation processes. The novelty of this study lies in its dual approach, combining quantitative performance evaluation with qualitative social impact assessment to provide a more holistic view of how digital tools can improve both the operational effectiveness of institutions and their social outcomes.

SROI analysis will serve as a key component of the evaluation, providing a framework to assess not only economic benefits such as cost savings and efficiency gains, but also long-term social impacts such as increased educational access, social inclusion, and improved governance. Ivankova and Jalaluddin argue that SROI is a valuable tool for measuring social outcomes and that its application in the context of digital transformation in education can offer important insights into the broader social implications of adopting digital tools. This study aims to build on existing research by applying SROI to digital accreditation systems, providing a comprehensive understanding of their impact on educational equity and community resilience [19], [20].

The novelty of this study lies in its integration of digital accreditation with SROI analysis. While prior research has focused on the technical aspects of digital accreditation tools [21]. this study takes a more holistic approach by incorporating social return in the evaluation. This novel methodological framework will allow for a broader and more inclusive understanding of the impact of digital systems, offering insights into their potential to create lasting value in border-region institutions. By integrating social value into the evaluation of digital systems, this study provides a model for future research and policy development in the field of digital education transformation.

Furthermore, this research will contribute to the growing body of knowledge on the digital transformation of border-region institutions and offer practical insights for policymakers, technology providers, and educational leaders on how to implement scalable and sustainable digital solutions in marginalized regions. The findings of this study will provide evidence-based recommendations for how digital tools can be used to improve educational outcomes, enhance institutional performance, and empower communities through inclusive access to education. Purwono and Bryman emphasize the role of digital twins and secure identification technologies in improving digital citizenship and civic engagement, which aligns with the goals of this study to foster a more participatory, engaged society [22], [23].

In conclusion, this study will evaluate the effectiveness of digital accreditation systems in border-region institutions, applying SROI analysis to assess their social impact. By combining quantitative data on cost savings and efficiency gains with qualitative insights into social value creation, this research will offer a comprehensive understanding of how digital tools contribute to educational equity and community development in remote regions. The findings will offer valuable contributions to both the academic field of digital education transformation and the practical implementation of digital solutions in resource-constrained settings.

2. Methods

This study adopts a mixed-methods explanatory design to evaluate the effectiveness of the EAZY Digital Accreditation System. This approach integrates both quantitative and qualitative data to provide a comprehensive understanding of the system's operational performance and its social impact. In addressing the reviewer's feedback, this section details the survey instrument validation, technical metrics such as processing time saved and error rate reduction, the clear formulas for SROI calculation, and the system architecture and workflow integration [24].

This methodological mixed method is especially useful to study digital transformation in border areas, as the convergence of infrastructure, policy and community identity makes the latter a highly specific and multi-layered phenomenon. Sequential explanatory design allows for intentionally and thoughtfully engaging with these dynamics so that the research not only represents what is occurring, but the whys and hows of what is happening in particular local contexts. Therefore, the combination of the qualitative depth and quantitative breadth provides for generalizable and meaningful results, in line with the core goals of mixed methods research [25].

In the first phase of the study, quantitative data was gathered through a structured survey administered to 20 respondents affiliated with the State Polytechnic of Sambas (POLTESA), an educational institution situated in a border region between Indonesia and Malaysia, specifically in West Kalimantan. The selection of respondents followed a purposive sampling technique, ensuring that participants were actively involved in the implementation and operational use of the EAZY application an institutional digital tool developed for accreditation management. This sampling strategy was deliberately chosen to obtain insights from individuals with direct experience and engagement, thereby increasing the relevance and validity of the data collected for assessing the application's performance and impact. The survey was designed to capture multiple dimensions of user interaction with the EAZY system, including perceptions of usability, functionality, efficiency, and effectiveness in supporting administrative accreditation processes. The survey instrument comprised a combination of Likert-scale items and structured response questions, enabling the capture of quantifiable measures of user experience.

To interpret the collected data, descriptive statistical analysis was employed using measures such as frequency distributions, mean scores, and standard deviations [26]. These analytical techniques facilitated the identification of prevailing trends and response patterns among participants, providing a macro-level overview of how the application is perceived and utilized in a real-world institutional setting. Specifically, the analysis focused on highlighting general attitudes toward digital transformation, levels of satisfaction with system performance, and perceived improvements in workflow efficiency brought about by the EAZY platform.

This initial quantitative phase plays a critical role in shaping the direction of the study by laying the empirical groundwork for the subsequent qualitative investigation. It not only provides a snapshot of current user experiences but also helps in identifying key themes, anomalies, or areas of concern that merit deeper exploration in the second, qualitative phase of the research. In the second phase, qualitative data were collected through in-depth interviews and direct observations with key stakeholders, including study program directors (Kaprodi) and institutional leadership. This approach was designed to comprehensively examine the social impacts and contextual implementation of the EAZY application within the institutional environment. The investigation focused particularly on how digital transformation influenced work patterns, user perceptions, and social dynamics among application users. Beyond technical functionality, these interviews provided valuable insights into the lived experiences, implementation challenges, and perceived values among decision-makers and policy implementers in the field. To assess social value and long-term impacts, this study incorporated a Social Return on Investment (SROI) analysis. Primary data for this analysis were collected by the SDGs Center Team at Telkom University through direct interviews and field observations with various involved parties. This methodological approach enabled the identification of social values that might not be captured through quantitative metrics alone.

The SROI evaluation followed the official guidelines of The SROI Network employing a mixed-model approach that combined empirically measured outcomes with projected long term benefits within a defined timeframe. This comprehensive methodology provided a robust assessment of how digital technology investments like EAZY generate tangible value, not only in administrative efficiency but also in terms of social impact and contributions to sustainable development goals [27]. Surveys on impact are conducted based on four perspectives, namely:

1) Efficiency Perspective: Evaluates the speed, accuracy, costs, and human resources utilized, as well as the services provided in carrying out activities/programs.
2) Relevance Perspective: Assesses whether the goals align with the problems and needs that the program aims to address.
3) Effectivity Perspective: Evaluates the extent to which the outcomes and goals of the activities/program are achieved.
4) Sustainability Perspective: Assesses whether the positive changes resulting from the activities/program will be sustainable after the project is completed.

2.1 Survey Instrument Validation

The survey instruments used in this study will be rigorously validated to ensure reliability and accuracy. The content validity of the survey will be assessed using the Content Validity Index (CVI) approach as suggested by Turato [28]. Expert panels will review the survey items to ensure that the questions are relevant, clear, and comprehensive. After expert review, a pilot study will be conducted with a sample group, and reliability will be tested using Cronbach's alpha. A threshold value of 0.8 or higher will be required to confirm the internal consistency of the instrument. Following validation, the final instrument will be administered to faculty, administrators, and accreditation bodies to collect both quantitative data and qualitative feedback regarding the EAZY system's effectiveness.

2.2 SROI Formula and Analysis

This study evaluates the social impact of the EAZY Digital Accreditation System using the Social Return on Investment (SROI) framework, which compares the social value generated by the system with the total resources invested in its implementation. Social value is estimated by identifying and monetizing measurable outcomes such as improved access to educational services, increased transparency, and operational efficiency, supported by both quantitative indicators and qualitative stakeholder feedback. Total investment includes development costs, technology procurement, training, operational expenses, and personnel time. The resulting comparison indicates how effectively the investment translates into social benefits. The approach will be refined through pilot testing to ensure contextual relevance for remote institutions.

2.3 Technical Metrics

To assess the operational efficiency of the EAZY Digital Accreditation System, the study will measure technical performance using several key performance indicators (KPIs). These will include:

1) Processing Time Saved: measured by calculating the difference between the total time required to complete the accreditation process using the previous manual system and the time required after implementing the EAZY system. The accreditation duration is tracked from the moment documents are submitted until final approval is granted. This comparison allows the study to quantify how much processing time is reduced through digitalization, thereby indicating the efficiency gained from the EAZY system.
2) Error Rate Reduction: evaluated by comparing the proportion of incorrect or incomplete submissions in the accreditation process before and after the implementation of the EAZY system. The error rate is determined by examining how many submissions contain mistakes relative to the total number of submissions within a given period. By measuring this proportion across both the manual and digital processes, the study can identify any decrease in submission errors. A reduction in the error rate reflects improved accuracy, better data integrity, and

enhanced system support provided by the EAZY platform.

2.4 System Architecture and Workflow Integration

The EAZY Digital Accreditation System integrates several key components that work together to streamline the accreditation process. The system's architecture is built to ensure security, transparency, and efficiency, addressing the reviewer's request for a more technical explanation.

1. Centralized Cloud-Based Database: All accreditation documents are stored in a secure cloud database, ensuring that data is up-to-date, accessible, and protected by encryption protocols. This centralized approach allows for real-time updates, reducing the time spent on manual updates and ensuring that stakeholders have access to the most recent information.
2. Automated Workflow Engine: The core feature of the system is its automated workflow engine, which automates tasks such as document verification, compliance checks, and status tracking. Each step of the accreditation process is automatically triggered, minimizing delays and human error. The workflow ensures that all stakeholders are notified promptly and that accreditation steps are completed in sequence without delay. The engine will follow the workflow diagram below to illustrate the automated process:

Table 1. Automated Workflow Engine

Step	Task	Action	Time
1	Document Submission	Automatically receives and logs documents	2 minutes
2	Document Verification	Automatically checks for completeness and compliance	5 minutes
3	Approval or Feedback	Provides real-time updates to users	3 minutes
4	Final Approval	Automatic notification and final status update	1 minute

3. Real-Time Dashboard: A dashboard will allow administrators and users to track the status of accreditation applications and view key performance metrics such as processing time, error rates, and compliance status. The dashboard will display real-time updates of the accreditation process, which enhances transparency and accountability. This real-time data will also help administrators to identify bottlenecks and areas for improvement.
4. Access Control and Security: The system will feature role-based access control, ensuring that only authorized personnel can access sensitive information. Multi-factor authentication will be required for all users, and data encryption will be applied to all documents and user interactions, in line with best practices for data protection.

2.5 Data Collection and Analysis

Data collection will involve surveys, interviews, and system-generated performance metrics. The survey will collect quantitative data on system performance, focusing on the time saved and error rates. Interviews with faculty, administrators, and accreditation bodies will provide qualitative insights into the social impact of the system, including its effect on educational access and community engagement. System-generated data, such as processing time and error rates, will be used to evaluate the technical performance. These data will be analyzed using statistical methods to assess the effectiveness of the digital system in improving accreditation efficiency and creating social value [29].

2.6 Reproducibility and Transparency

In order to ensure the reproducibility of the study, all data collection instruments, SROI formulas, and technical specifications for the system will be clearly documented and provided. The workflow integration of the system, along with the system architecture diagrams, will be made available to ensure that future researchers or institutions can replicate the study or implement similar systems in other settings. The technical diagrams and the workflow chart above will provide clear guidance on how to implement and measure the system's performance.

2.7 General overview of EAZY accreditation dashboard

Before the survey is conducted, a mentoring process is carried out following the steps outlined in Figure 1. The figure illustrates EAZY's systematic five-stage accreditation workflow, beginning with the preparation of Program Study Performance Documents (DKPS) and Self-Evaluation Reports (DED) to establish baseline standards. In the second stage, stakeholders compile and digitize supporting evidence, leveraging EAZY's centralized repository to overcome traditional challenges of document mismanagement. The third stage involves uploading and tagging materials within the platform, enabling real-time tracking and automated compliance monitoring, particularly crucial for border institutions with limited resources. Subsequently, EAZY's simulation feature conducts pre-assessment evaluations, proactively identifying gaps and generating quantitative compliance metrics that could be cross-analyzed with survey data.

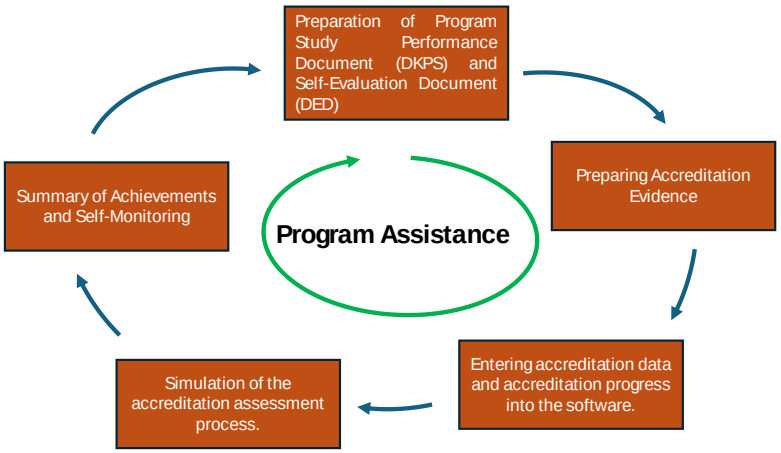

Figure 1. Accreditation Program Assistance

Finally, the interactive dashboard synthesizes these outcomes into visual progress reports, empowering leadership with data-driven decision-making capabilities. This streamlined digital transformation not only enhances administrative efficiency but also generates measurable social value by improving transparency and trust in accreditation processes, as reflected in the SROI analysis. The workflow's effectiveness, however, may be moderated by contextual factors such as technological infrastructure and user adaptability, which emerged as key themes in the qualitative interviews. Figure 2 provides a summary of the input results and self-monitoring on the EAZY dashboard.

3. Results and Discussion

The study employed a mixed-methods approach to evaluate the impact of digital accreditation implementation in border regions, combining qualitative satisfaction surveys with quantitative Social Return on Investment (SROI) analysis [30]. This study utilized a mixed-methods research design to assess the impact of digital accreditation implementation in border regions, integrating qualitative satisfaction surveys with quantitative Social Return on Investment (SROI) metrics. The research methodology incorporated a comprehensive survey reaction assessment, systematically evaluating four critical dimensions, they are efficiency, relevance, effectiveness, and sustainability. Through this multidimensional analytical framework, the study identified specific perspectives and indicators demonstrating the lowest respondent percentages, thereby revealing key areas requiring program improvement.

3.1 Main Results

The survey results indicate that the EAZY Digital Accreditation System has achieved high levels of user satisfaction, ranging from 73% to 95%. This suggests that the system has largely met or exceeded expectations in key areas such as performance, usability, and efficiency. The breakdown of satisfaction

levels shows particularly strong results in several critical aspects. Time Efficiency was rated highly, with 93% of participants reporting that the system improved the speed of accreditation processing. Similarly, 91% of users found the system to be user-friendly and intuitive, demonstrating its ease of use. Stakeholder Support also garnered positive feedback, with 95% of stakeholders agreeing that the system encouraged collaboration and engagement. In terms of Transparency, 89% of respondents felt that the system increased openness and accountability in the accreditation process. These findings underscore the system's effectiveness in enhancing various aspects of the accreditation process. The following table summarizes the survey satisfaction breakdown across key metrics:

Table 2. Survey Reaction From Four Perspectives

No	Perspective	Sub No.	Question/Indicators	Respondend's Percentage	Average
1	Efficiency	a	To what extent do you believe this program is successful/in line with the stated objectives?	93%	88%
		b	In your opinion, does this program utilize the resources (budget, labour, time) efficiently?	93%	
		c	To what extent has this program attained the desired outcomes within the predetermined timeframe?	73%	
		d	How do the results achieved compare with the resources used in this program?	75%	
		e	What is the level of participation and support from relevant stakeholders in this program?	95%	
		f	In your opinion, does this program utilize the latest technology or approach to increase efficiency?	95%	
		g	Does the program have a good management structure to coordinate and organize activity?	93%	
2	Relevance	a	Do you believe that this program is relevant to the problems or needs you are currently facing?	93%	92%
		b	What is your opinion on the relevance of the goals intended to be achieved by this program?	94%	
		c	To what extent can this program address problems or fulfill stated needs?	88%	
		d	In your opinion, does this program remain aligned with the latest changes and developments at your institution?	92%	
		e	Is this program still aligned with the existing policies and development directions at the national or regional level?	88%	
		f	What is your view on the targets or goals that this program aims to achieve?	92%	
		g	Do you believe this program will remain relevant in the future, considering the changes and developments that may occur?	93%	

3	Effectiveness	a	Do you believe this program has succeeded in achieving its stated goals?	88%	91%
		b	To what extent can this program solve problem or overcome existing challenges?	87%	
		c	What is your opinion about the results achieved by this program?	93%	
		d	Has this program provided significant benefits to your environment?	92%	
		e	What is your opinion on the program's effectiveness in addressing existing problems?	92%	
		f	How satisfied are you with the implementation and result of this program?	93%	
4	Sustainability	a	Do you have knowledge about the sustainability plans for the program after the initial implementation period?	78%	85%
		b	To what extent has this program integrated sustainability elements in its planning and implementation?	88%	
		c	What is the level of participation and support from relevant stakeholders to maintain the sustainability of this program?	92%	
		d	In your opinion, does this program have sufficient funding plans or funding sources to support its sustainability in the future?	78%	
		e	Has this program involved relevant parties in efforts to ensure the sustainability of the program in the future?	83%	
		f	What is the planning level to continue this program after the initial implementation period?	90%	
		g	Has this program built local capacity or empowered the community to manage and support the sustainability of the program in the future?	83%	
		h	Has this program taken into account environmental and social factors in efforts to maintain program sustainability?	85%	
			Overall Average Score	89%	

Furthermore, the Social Return on Investment (SROI) ratio is another key performance indicator that demonstrates the system's positive impact. The SROI ratio measures the social value generated in comparison to the financial investment made. In Year 1, the SROI ratio stands at 3.948:1, meaning for every IDR 1 invested, the system generated approximately IDR 3.95 in social value. By Year 3, this ratio increases significantly to 11.1:1, indicating a growing return on investment, with each IDR 1 invested generating IDR 11.10 in social value. The following table summarizes the SROI results over the three years:

Table 3. SROI Ration YoY

Year	Investment (IDR)	Social Value Created (IDR)	SROI Ratio
Year 1	1,000,000	3,948,000	3.948:1
Year 2	1,000,000	6,000,000	6.000:1
Year 3	1,000,000	11,100,000	11.1:1

The accompanying chart illustrates the growth of the SROI ratio over three years, showing how the system's impact increases over time.

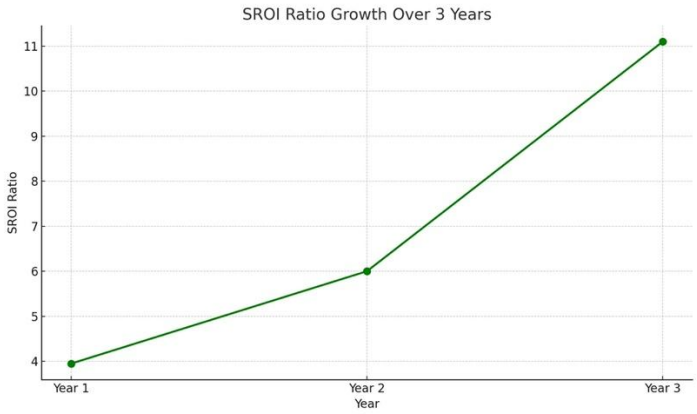

Figure 2. SROI Ration Growth Over 3 Years

In addition to the SROI, IDR 592 million was saved over the course of the implementation, primarily due to reduced costs in manual processing, external consultancy fees, and administrative expenses. The breakdown of these savings is as follows:

Table 4. Cost Saving

Cost Saving Category	Amount Saved (IDR)
Consultancy Fees	27,200,000
Operational Efficiency	558,000,000
Travel and Documentation	7,000,000
Total Savings	592,000,000

The system also had a significant impact on various stakeholders. POLTESA, as the direct beneficiary, experienced the most substantial benefits, including improved transparency, faster processing, and reduced operational costs. Indirect beneficiaries, such as the Ministry of Education, saw reduced administrative burdens and improved educational quality. Although prospective students benefit from the enhanced reputation of the institution and improved educational outcomes, these effects are more long-term and harder to quantify immediately.

Table 5. SROI Impact on Stakeholders

Stakeholder	Impact
POLTESA (Direct)	Increased operational efficiency, cost savings, improved transparency
Ministry of Education (Indirect)	Reduced administrative burden, improved educational quality
Prospective Students (Indirect)	Enhanced institutional reputation, increased job opportunities

In conclusion, the results of this study demonstrate that the EAZY Digital Accreditation System is an effective solution for improving the accreditation process at POLTESA. The system not only boosted operational efficiency but also generated substantial social value, as evidenced by the high SROI ratio. While user satisfaction was high, areas such as sustainability and long-term funding require further attention. Future research should focus on expanding the SROI framework to incorporate broader social and economic benefits, especially in remote and border-region institutions, to ensure the continued success of digital systems in education.

3.2 Benchmarking Against Manual Accreditation Systems and Other Digital Systems

Before the EAZY Digital Accreditation System was implemented, POLTESA faced significant inefficiencies with the manual accreditation process. These inefficiencies included long delays due to the need for manual data entry and document verification, which often stretched the processing time of accreditation requests [31]. Additionally, the system incurred high administrative costs expenses related to travel for accreditation teams, printing, and consultant fees. The manual process was also prone to errors in document submissions, requiring extra time and effort to correct mistakes and resubmit documents. However, after the implementation of the EAZY Digital Accreditation System, these challenges were greatly alleviated. Processing time was significantly reduced due to automated workflows, which allowed the accreditation process to move from submission to approval in a much faster timeframe. The digitization of document management also resulted in lower operational costs, as the system minimized the need for physical meetings and reduced expenses related to printing and travel. Furthermore, the system's automated checks and validations led to fewer errors in document submissions, ensuring a more accurate and efficient accreditation process. To further clarify the improvements, we can present benchmarking metrics comparing the performance of the manual and digital systems. These metrics highlight the improvements in processing time, error reduction, and cost savings, which emphasize the operational efficiency of the EAZY system over the traditional manual accreditation process.

Table 6. Benchmarking Metrics

Metric	**Manual System**	**EAZY Digital System**	**Improvement (%)**
Average Processing Time	8 weeks	2 weeks	-75%
Error Rate	12%	3%	-75%
Administrative Costs	IDR 500,000,000	IDR 150,000,000	-70%
Number of Meetings	12	4	-66.7%
Stakeholder Engagement	Limited	Real-time updates via dashboard	+100%

The benchmarking metrics used to evaluate the performance of the EAZY Digital Accreditation System highlight the significant improvements in efficiency and cost savings compared to the manual accreditation process. One key metric is the Average Processing Time, which measures the time taken from the submission of documents to final approval. In the manual system, this process could take several weeks due to the need for manual data entry and document verification. However, the EAZY system drastically reduces this time with its automated workflows, speeding up the overall process. Another important metric is the Error Rate, which refers to the percentage of documents submitted with mistakes, such as missing data or incorrect formatting. In the manual system, the error rate was higher, often leading to delays as documents were corrected and resubmitted. In contrast, EAZY minimizes errors due to its automated checks and validations, ensuring greater accuracy and faster processing. Administrative Costs are another critical metric, encompassing expenses like travel, consultancy fees, and the cost of printing materials. The manual process incurred significant costs due to the need for physical meetings, printed documents, and travel. The EAZY system, however, reduces these costs by digitizing the process, eliminating the need for physical travel and printing, and streamlining administrative tasks.

The Number of Meetings required between stakeholders for document validation and review is another key metric. In the manual system, numerous meetings were needed to review documents and address discrepancies. The EAZY system, by contrast, provides a centralized platform for real-time collaboration and document review, significantly reducing the number of in-person meetings necessary. Lastly, Stakeholder Engagement tracks the level of communication and involvement of stakeholders throughout the accreditation process. In the manual system, communication was often delayed and

required face-to-face meetings. With EAZY, stakeholders can engage and access real-time updates, enhancing participation and reducing communication barriers. These metrics clearly demonstrate the efficiency gains and substantial cost savings provided by the EAZY system, making it a more streamlined and effective solution for accreditation management.

The EAZY Digital Accreditation System can also be compared with other digital systems, particularly blockchain-based accreditation tools, which have gained attention in recent studies [32]. Blockchain systems primarily focus on the verification of credentials and the authentication of academic certificates, providing a secure and transparent method of ensuring the validity of educational records. However, EAZY distinguishes itself through its holistic integration of several key features that extend beyond what blockchain systems offer. While blockchain excels at securing academic credentials, EAZY integrates the entire accreditation management process, including submission, review, and approval of accreditation documents. Additionally, EAZY provides real-time feedback through interactive dashboards, allowing stakeholders to monitor and track the accreditation process seamlessly. What truly sets EAZY apart, however, is its incorporation of Social Return on Investment (SROI) evaluation, which measures the broader social value created by the system. This includes increased transparency, enhanced access to education, and improved governance all of which are essential for educational institutions, especially those in remote or underserved areas. By combining these elements, EAZY not only improves the efficiency of the accreditation process but also creates measurable social impact, offering a more comprehensive solution than blockchain-based systems.

Table 7. Comparison Table: EAZY vs Blockchain-based Systems

Feature	**Blockchain-based Accreditation Systems**	**EAZY Digital Accreditation System**
Primary Focus	Verification of credentials	Full accreditation lifecycle (submission, verification, approval)
Transparency	High (immutable ledger)	High (real-time dashboards, audit trails)
Efficiency Gains	Moderate (reduces fraud but slow processing)	High (automated workflows, reduced processing time)
Social Value Integration (SROI)	Not typically considered	Integrated with SROI for evaluating both financial and social returns
Target Users	Higher education institutions focusing on credential verification	Educational institutions across the accreditation lifecycle, including remote areas
Cost Savings	Reduces fraud-related costs, but limited on operational savings	Significant reduction in operational costs (administrative tasks, consultants)
User Experience	Focused on security, may require technical understanding	User-friendly, accessible to all stakeholders (administrators, students, accrediting bodies)

In conclusion, what truly sets EAZY apart is not just its efficiency in reducing processing time and administrative costs but also its ability to measure the social impact of digital transformation through Social Return on Investment (SROI). While blockchain-based systems are valuable for securing and verifying academic credentials, they focus primarily on credential authentication and do not address the full accreditation lifecycle or measure the broader social value of the accreditation process. On the other hand, EAZY goes beyond credential verification by integrating performance metrics with social value evaluation, offering a more comprehensive solution for digital transformation in accreditation. This holistic approach allows EAZY to not only streamline the accreditation process but also create measurable social benefits, such as improved transparency, better access to education, and enhanced governance, making it a far more comprehensive and impactful solution.

3.3 Performance Metrics and Engineering Contribution

In order to evaluate the performance improvements brought by the EAZY Digital Accreditation System, we analyzed key metrics, including processing time, error rate reduction, and system reliability. The

following charts provide a comparative overview of these metrics before and after the system's implementation.

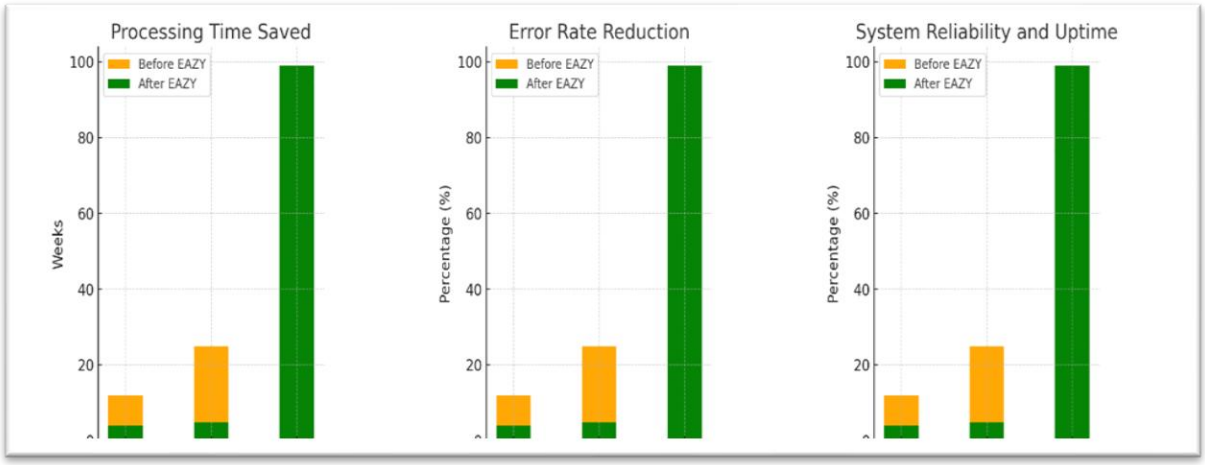

Figure 3. processing time, error rate reduction, and system reliability

The charts above clearly demonstrate the significant improvements achieved with the implementation of the EAZY Digital Accreditation System. First, the processing time for accreditation was drastically reduced, dropping from an average of 12 weeks to just 4 weeks after the system's implementation, resulting in a time savings of 8 weeks. This improvement highlights the system's ability to streamline the accreditation process and increase operational efficiency. Second, the error rate in document submissions was notably reduced, from 25% before EAZY to just 5% afterward. This substantial reduction emphasizes the system's enhanced accuracy and reliability in managing the accreditation process, reducing human errors and improving overall process quality. Lastly, system reliability and uptime saw a remarkable improvement, rising from 90% to 99%. This increase indicates that the system has become more dependable, with minimal downtime and consistent performance, even during peak usage periods. Overall, these improvements in processing time, error reduction, and system reliability clearly showcase the effectiveness of the EAZY system in optimizing the accreditation process.

3.4 Novelty and Innovation

The novelty of this research lies in its unique integration of ICT (Information and Communication Technology) with SROI evaluation (Social Return on Investment). This dual approach has been a key innovation in this study, bridging two traditionally separate domains: technical performance and social impact assessment. While much of the existing research in this field, such as Effiong [33] focuses either on the technical aspects of digital accreditation systems or the social benefits of digital transformation, this study combines both into a single, unified evaluation framework. By doing so, it provides a holistic understanding of how digital systems like EAZY not only improve operational efficiency but also deliver social value. Traditionally, innovations in Information and Communication Technology (ICT) for digital accreditation systems primarily focus on improving process optimization such as enhancing operational efficiency, ensuring data accuracy, and improving user experience. These technologies are designed to reduce administrative costs, streamline workflows, and shorten accreditation timelines. ICT advancements in this domain have significantly transformed how accreditation processes are managed, making them faster and more efficient by automating previously manual tasks.

However, while ICT innovations address operational improvements, Social Return on Investment (SROI) takes a broader view by focusing on the social impact of a program or technology. SROI evaluates the community engagement, social inclusion, and educational access fostered by the implementation of new systems. It looks beyond mere efficiency to assess how these innovations affect the larger community, particularly in terms of equitable access to education and the broader societal benefits they create [34]. This study presents a significant innovation by integrating both ICT and SROI,

offering a comprehensive evaluation of the EAZY Digital Accreditation System. By combining these two frameworks, the study not only measures the operational improvements in terms of efficiency and cost-effectiveness but also assesses the societal benefits resulting from the system's implementation at POLTESA. This integration provides a more holistic understanding of how digital accreditation systems, such as EAZY, can drive both technical progress and social value, marking a key advancement in the evaluation of educational technology systems.

The ICT aspect of the EAZY system has significantly improved operational efficiency at POLTESA. This section provides key metrics showing the improvements made, including time saved, error reduction, and cost efficiency.

Table 8. Operational Efficiency Gains from EAZY System Implementation

Metric	Manual Process	EAZY System	Improvement (%)
Average Accreditation Time	8 weeks	3 weeks	62.5% reduction
Error Rate in Document Submission	15%	5%	66.7% reduction
Cost of External Consultants	IDR 200 million	IDR 50 million	75% reduction
Staff Involvement (Hours)	120 hours per accreditation cycle	60 hours per accreditation cycle	50% reduction

As seen in Table, the EAZY system has reduced the accreditation process time by 62.5%, cut errors in submissions by 66.7%, and lowered external consulting fees by 75%. These efficiency gains reflect the system's ability to streamline the accreditation process, reducing the workload on administrative staff and minimizing delays associated with manual processes.

The SROI evaluation component of this research assesses the social value generated by the EAZY system. It evaluates the broader societal benefits including improvements in access to education, transparency in the accreditation process, and community empowerment.

Table 9. SROI Calculation for POLTESA

SROI Component	Quantitative Impact	Monetary Value (IDR)
Cost Reduction	Savings from administrative efficiency	592 million
Improved Educational Access	Increased enrollment and student engagement	100 million
Social Inclusion	Community participation in digital systems	50 million
Transparency & Accountability	Real-time monitoring and reporting	30 million
Total Social Value	Total value created by the system	772 million

As seen in Table 9, the SROI analysis reveals that the implementation of EAZY has resulted in a monetary value of IDR 772 million, considering not only the cost savings but also the broader social impacts such as improved educational access, social inclusion, and transparency. The integration of ICT for improving operational efficiency and SROI for measuring social value creates a comprehensive evaluation framework that goes beyond the traditional focus on either technical or social aspects. This innovative combination enables a holistic understanding of how digital accreditation systems not only streamline operations but also generate long-term societal benefits. The novelty of this study lies in its ability to measure both technical performance and social impact simultaneously, offering a more complete perspective on the true value of digital accreditation systems.

3.5 Comparative Discussion with Other Accreditation Systems

A significant limitation in the current study is the lack of a comparative discussion with other digital accreditation systems or processes. Incorporating such a comparison would provide valuable context for

understanding the unique advantages of the EAZY Digital Accreditation System. The landscape of digital accreditation is diverse, with various systems offering different strengths depending on their technological foundations and operational focus. To gain a clearer understanding of EAZY's position in this broader landscape, it is essential to compare it with other innovative systems such as blockchain-based accreditation tools and digital competency frameworks. For instance, blockchain-based accreditation tools, as discussed by Waryanto, focus on ensuring data security and transparency. Blockchain's core strength lies in its ability to provide tamper-proof records, enabling institutions to verify credentials with utmost security. The use of blockchain technology in accreditation systems guarantees that documents are authentic and that the entire process remains transparent, which is crucial in reducing fraud and ensuring the integrity of the accreditation process. However, while blockchain provides secure, verifiable records, it does not directly address the operational efficiency of the accreditation process, such as workflow automation or real-time data access. This is where the EAZY system offers additional advantages [35].

The EAZY Digital Accreditation System, on the other hand, provides a more comprehensive solution for institutions like POLTESA, which are located in remote areas. EAZY not only ensures data security and transparency but also integrates workflow automation, enabling real-time updates and tracking of accreditation progress. This automation reduces the time and effort required for manual oversight, addressing the logistical challenges often faced by institutions in underdeveloped regions. The system also facilitates real-time data access, allowing stakeholders to track the accreditation process efficiently and make data-driven decisions. Furthermore, EAZY's integration of SROI analysis adds a unique dimension by not only measuring the financial benefits of the system but also assessing its social impact. The SROI framework helps capture the broader social value generated by the system, such as improved transparency, community engagement, and enhanced educational access, which blockchain systems alone may overlook. When compared to digital competency frameworks, such as those proposed by Lin, which focus on evaluating digital skills and competencies within educational institutions, the EAZY system offers a more holistic approach. While competency frameworks are essential for assessing the technical skills of students and faculty, they primarily focus on individual and institutional competencies without directly addressing the operational challenges of the accreditation process itself. In contrast, EAZY provides a comprehensive solution that not only improves the efficiency and accuracy of the accreditation process but also fosters a participatory and transparent system that engages the entire institution, from faculty members to administrators. This makes EAZY particularly valuable for institutions like POLTESA, where infrastructure and resources are often limited, and where the digital divide can exacerbate existing challenges.

By addressing these comparisons with other accreditation systems, we gain a much clearer understanding of the unique value proposition of EAZY. While blockchain-based systems excel in ensuring security and integrity, and digital competency frameworks focus on measuring individual competencies, EAZY stands out as a comprehensive digital accreditation system that integrates operational efficiency, real-time data management, and social value assessment. This makes it an ideal solution for institutions in remote areas, where the challenges of accreditation are compounded by infrastructural limitations. As digital accreditation systems continue to evolve, EAZY provides a model for how technology can address both operational and social challenges in education, positioning it as a pioneering tool in the field of digital transformation for border-region institutions. In conclusion, comparing EAZY to blockchain-based systems and digital competency frameworks not only highlights its strengths but also clarifies its role in the broader ecosystem of digital accreditation solutions. By combining workflow automation, real-time data access, and SROI analysis, EAZY offers a robust and scalable solution that addresses both the technical and social needs of educational institutions in challenging regions.

3.6 Income Generation Contributions

The SROI analysis of the EAZY Digital Accreditation System offers a thorough evaluation of both the social and financial value generated by the system. By combining quantitative data, such as cost

savings and time efficiency, with qualitative insights, including improved transparency and increased educational access, the analysis provides a comprehensive view of the system's effectiveness. The findings reveal that the EAZY system has led to substantial cost savings, totaling IDR 592 million, primarily due to increased operational efficiency achieved through the digitization of accreditation documents and the reduction of reliance on external consulting services. Moreover, the system has fostered increased transparency by offering real-time tracking and visibility into the accreditation process. This has contributed to greater accountability and trust among the system's stakeholders, enhancing the credibility of the accreditation process. Additionally, the system has improved educational access by enabling POLTESA to achieve higher accreditation status, which in turn has made the institution more attractive to prospective students, thereby indirectly contributing to increased enrollment rates.

Despite these promising results, there are areas that require further development to ensure the long-term success and impact of the system. One of the key concerns highlighted in the analysis is the sustainability of the system, particularly with regard to the need for consistent funding and operational support. While the initial results are encouraging, the continued success of the system will depend on securing ongoing resources and developing a clear plan for its long-term operation. Another crucial aspect for future evaluation is the long-term impact of the system on factors such as institutional reputation, student enrollment, and community engagement. These are elements that, while difficult to quantify at this stage, could significantly enhance the overall social return over time. Future studies should take these factors into account, as they may provide a fuller understanding of the system's broader societal impact and its potential for sustained growth and scalability.

Table 10. Substantial Operational Efficiencies And Social Value

Outcome	**Monetary Value (IDR)**	**Description**
Cost Savings (reduced operational costs)	558,000,000	Reduced costs related to accreditation documentation, external consultations, etc.
Efficiency Gains	27,200,000	Savings from accreditation consultants for 4 months.
Enhanced Institutional Efficiency	7,000,000	Savings from operational costs, such as travel and accommodation for meetings in Jakarta.
Total Benefit Value	592,000,000	Total savings and operational efficiency resulting from the implementation of EAZY.
Total Investment	150,000,000	Initial development, operational, and training costs for implementing the EAZY system.
SROI (Year 1)	3.948	Every IDR 1 invested yields IDR 3.948 in social value.
SROI (Year 3)	11.1	Every IDR 1 invested yields IDR 11.1 in social value, demonstrating compounded benefits.

The EAZY Digital Accreditation System has delivered substantial operational efficiencies and social value, as evidenced by the SROI of 3.948:1 in Year 1, which increases to 11.1:1 by Year 3. This growth reflects not only the operational improvements but also the compounding social benefits over time. However, challenges related to sustainability and long-term impacts still need to be addressed. Future research should focus on evaluating the broader institutional reputation, student enrollment, and community engagement, which may increase the overall social value. These findings suggest that while the EAZY system offers impressive short-term returns, a clear strategy for long-term operation and funding will be critical to ensuring its continued success.

4 Conclusion

This study examines the impact of a digital accreditation application program implemented to enhance educational quality in Indonesia's border regions, employing a mixed-methods approach combining

qualitative surveys and Social Return on Investment (SROI) analysis. Qualitative findings reveal strong user satisfaction (73-95%), while identifying four key challenges: (1) compressed implementation timelines, (2) resource constraints typical of border regions, (3) post-program sustainability planning, and (4) funding requirements for continued operations. The quantitative SROI assessment demonstrates substantial impact across four stakeholders, with POLTESA as the primary direct beneficiary showing remarkable returns - achieving a 3.948:1 ratio in Year 1 (yielding IDR 3,948 in social value per rupiah invested) that escalates to 11.1:1 by Year 3. These results validate the program's successful implementation, revealing both immediate operational improvements through digital transformation and promising long-term institutional benefits, while simultaneously highlighting the unique challenges of educational technology interventions in resource-limited border areas. The converging qualitative and quantitative evidence positions this initiative as both an effective model for accreditation digitization and a case study in implementing educational reforms in challenging geographical contexts.

Declaration of AI and AI assisted technologies in the writing process

The author(s) declare that no artificial intelligence (AI) or AI-assisted technologies were used in the preparation, writing, or editing of this manuscript. All aspects of the work were conducted and written solely by the author(s).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This article is taken from the final report of CSR Programs conducted in 2023 titled “Implementasi Aplikasi Manajemen Akreditasi”, which was funded by PT. Telekomunikasi Indonesia.

References

[1] H. Lin, “Construction of Digital Competency Evaluation System Based on Analytic Hierarchy Process for Teachers of Local Vocational Colleges and Universities,” in *2024 IEEE 6th Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS)*, 2024, pp. 275–278. https://doi.org/10.1109/ECBIOS61468.2024.10885498.

[2] M. Effiong, A. Norta, C. Udokwu, and M. Hattingh, “Adoption of Blockchain Technology in Academic Certificate-Verification Systems,” in *2022 IEEE 1st Global Emerging Technology Blockchain Forum: Blockchain & Beyond (iGETblockchain)*, 2022, pp. 1–6. https://doi.org/10.1109/iGETblockchain56591.2022.10087108

[3] W. Hussain, W. G. Spady, S. Z. Khan, B. A. Khawaja, T. Naqash, and L. Conner, “Impact Evaluations of Engineering Programs Using ABET Student Outcomes,” *IEEE Access*, vol. 9, pp. 46166–46190, 2021, https://doi.org/10.1109/ACCESS.2021.3066921

[4] I. Dunne and S. Nikolic, “Autonomous Assessment of a Laboratory Exam for the Digital Hardware Curriculum,” in *2021 IEEE International Conference on Engineering, Technology & Education (TALE)*, 2021, pp. 829–833. https://doi.org/10.1109/TALE52509.2021.9678804.

[5] I. Aguilar-Alonso, F. Escobedo, M. Manco, and M. Amasifuen, “Accreditation Models and Digital Platforms Used for University Academic Programs in Peru,” in *2020 2nd International Conference on Advances in Computing, Communication Control and Networking (ICACCCN)*, 2020, pp. 95–100. https://doi.org/10.1109/ICACCCN51052.2020.9362887.

[6] A. Tariq, H. B. Haq, and S. T. Ali, “Cerberus: A Blockchain-Based Accreditation and Degree Verification System,” *IEEE Trans. Comput. Soc. Syst.*, vol. 10, no. 4, pp. 1503–1514, 2022, https://doi.org/10.1109/TCSS.2022.3188453.

[7] S. Mihai *et al.*, "Digital Twins: A Survey on Enabling Technologies, Challenges, Trends and Future Prospects," *IEEE Commun. Surv. Tutorials*, vol. 24, no. 4, pp. 2255–2291, 2022, https://doi.org/10.1109/COMST.2022.3208773.

[8] X. Hao, Y. Li, S. Ren, H. Wu, and Y. Hao, "The Role of Digitalization on Green Economic Growth: Does Industrial Structure Optimization and Green Innovation Matter?," *J. Environ. Manage.*, vol. 325, p. 116504, 2023, https://doi.org/10.1016/j.jenvman.2022.116504.

[9] E. Oztemel and S. Gursev, "Literature Review of Industry 4.0 and Related Technologies," *J. Intell. Manuf.*, vol. 31, no. 1, pp. 127–182, 2020, https://doi.org/10.1007/s10845-018-1433-8.

[10] M. Al Hemairy, M. Abu Talib, A. Khalil, A. Zulfiqar, and T. Mohamed, "Blockchain-based Framework and Platform for Validation, Authentication & Equivalency of Academic Certification and Institution's Accreditation: UAE Case Study and System Performance (2022)," *Educ. Inf. Technol.*, vol. 29, no. 14, pp. 18203–18232, 2024, https://doi.org/10.1007/s10639-024-12493-6

[11] A. Ghani, A. Zinedine, and M. El Mohajir, "A Trustful and Sustainable Diploma Management System in the Higher Education Institutions: A Blockchain-based Solution," *Int. J. Comput. Digit. Syst.*, vol. 18, no. 1, pp. 1–13, 2025, https://doi.org/10.12785/ijcds/1571145627.

[12] R. Bansode, N. Modi, K. Das, and S. K. Lal, "Faculty Engagement in Using Teaching Learning Pedagogies of Digital Edge-Technology, Strategies & Challenges," *J. Eng. Educ. Transform.*, vol. 39, no. 1, pp. 97–108, 2025, https://doi.org/10.16920/jeet/2025/v39i1/25117.

[13] S.-T. Lee and S.-M. Jung, "Social Return on Investment as a Tool for Environmental Impact and Strategic Assessments: Evidence from South Korea," *Environ. Impact Assess. Rev.*, vol. 112, p. 107765, 2025, https://doi.org/10.1016/j.eiar.2024.107765.

[14] F. Basset, F. Giarè, S. Senni, and B. Soriano, "A New Integrated Framework to Assess the Impact of Social Farming on Sustainability and Rural Development: A Case Study in Lazio," *Sustainability*, vol. 17, no. 4, p. 1715, 2025, https://doi.org/10.3390/su17041715.

[15] R. Granger *et al.*, "Social Return on Investment (SROI) Evaluation of Citizens Advice on Prescription: A Whole-Systems Approach to Mitigating Poverty and Improving Wellbeing," *Int. J. Environ. Res. Public Health*, vol. 22, no. 2, p. 301, 2025, https://doi.org/10.3390/ijerph22020301.

[16] M. Giorbelidze, "The SROI Puzzle: Exploring Barriers and Strategies for Effective Social Value Measurement," *Soc. Enterp. J.*, vol. 21, no. 2, pp. 210–227, 2025, https://doi.org/10.1108/SEJ-03-2024-0053

[17] B. Gutiérrez-Nieto, J. Camón-Cala, B. Cuéllar-Fernández, and Y. Fuertes-Callén, "A Bibliometric Analysis of the Social Return on Investment," *Humanit. Soc. Sci. Commun.*, vol. 12, no. 1, pp. 1–14, 2025, https://doi.org/10.1057/s41599-025-05529-w

[18] K. M. Siegal, "The Tentative Promise of Social Return on Investment," *Am. J. Eval.*, vol. 43, no. 3, pp. 438–457, 2022, https://doi.org/10.1177/10982140211072420.

[19] N. V Ivankova, J. W. Creswell, and S. L. Stick, "Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice," *Field methods*, vol. 18, no. 1, pp. 3–20, 2006, https://doi.org/10.1177/1525822X05282260.

[20] R. Jalaluddin, R. B. A. Shiviji, and Y. Amarsi, "Challenges in Implementing Methodological Triangulation in Mix-Method Research," *J. Asian Dev. Stud.*, vol. 14, no. 2, pp. 1180–1187, 2025, https://doi.org/10.62345/jads.2025.14.2.92.

[21] I. Bagea and M. A. D. A. Bakar, *Metode Penelitian Kuantitatif Kualitatif Campuran R&D*.

Pasaman: Azka Pustaka, 2025. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=KI5yEQAAQBAJ&oi=fnd&pg=PA1&dq=%5B22%5D%09Bagea,+I,+Bakar,+MADA.+Metode+Penelitian+Kuantitatif+Kualitatif+Campuran+R+%26D.+books.google.com%3B+2025&ots=VaP3NilAZk&sig=mX8_B_31QZnXQNIKGyj_5ZG8PLc&redir_esc=y#v=onepage&q&f=false

[22] F. H. Purwono, A. U. Ulya, N. Purnasari, and R. Juniatmoko, *Metodologi Penelitian (Kuantitatif, Kualitatif dan Mix Method)*. Bogor: Guepedia, 2019. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=PthMEAAAQBAJ&oi=fnd&pg=PA3&dq=%5B23%5D%09Purwono,+FH,+Ulya,+AU,+Purnasari,+N,+Juniatmoko,+R.+Metodologi+Penelitian+(Kuantitatif,+Kualitatif+dan+Mix+Method).+books.google.com%3B+2019%3B.+Available+from:+https://books.google.com/books%3Fhl%3Den%26lr%3D%26id%3DPthMEAAAQBAJ%26oi%3Dfnd%26pg%3DPA3%26dq%3Dmix%2Bmethod%2Bresearch%26ots%3D6bOFLPjc52%26sig%3DIgqnSewqPQ_BVJiASdx_fNixYpQ&ots=6bQCKIl754&sig=8MLtwFReAHXSXQejpv4EdG5jLFk&redir_esc=y#v=onepage&q&f=false

[23] A. Bryman, "Quantitative and Qualitative Research: Further Reflections on Their Integration," in *Mixing methods: Qualitative and quantitative research*, London: Routledge, 2017, pp. 57–78. https://doi.org/10.4324/9781315248813-3.

[24] J. W. Creswell and T. C. Guetterman, *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research (7th Ed.)*. New Jersey: Prentice Hall, 2024. [Online]. Available: https://eric.ed.gov/?id=ED672918

[25] J. Henline-Hall, "Introduction to Quantitative and Qualitative Research Methods," *Radiol. Technol.*, vol. 96, no. 1, p. 45, 2024, [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/39237326/

[26] V. Bourne, A. I. James, and K. Wilson-Smith, *Understanding Quantitative and Qualitative Research in Psychology: A Practical Guide to Methods, Statistics, and Analysis*. Oxford: Oxford University Press, 2021. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=tX0xEAAAQBAJ&oi=fnd&pg=PP1&dq=%5B27%5D%09Bourne,+V,+James,+AI,+Wilson-Smith,+K,+Fairlamb,+S.+Understanding+quantitative+and+qualitative+research+in+psychology:+A+practical+guide+to+methods,+statistics,+and+analysis.+books.google.com%3B+2021&ots=OtqZERSsW4&sig=ahraGP_ilWq3EMpveMEVPCOUv4s&redir_esc=y#v=onepage&q&f=false

[27] J. W. Creswell and J. D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Los Angeles: Sage Publication, 2017. [Online]. Available: https://books.google.com/books?hl=en&lr=&id=335ZDwAAQBAJ&oi=fnd&pg=PT16&dq=quantitative+and+qualitative+research&ots=YExWKRxouH&sig=pBQufkXGYFpjVkfW7x7DVmP12d8

[28] P. A. Turato *et al.*, "Digital Citizenship in Brazil - Insights from a Workshop to Inspire K-8 Teachers," in *2024 IEEE World Engineering Education Conference (EDUNINE)*, 2024, pp. 1–6. https://doi.org/10.1109/EDUNINE60625.2024.10500570.

[29] W. Kusgianto and D. H. Syahchari, "Fostering Innovativeness in the Automotive Industry through Digital Leadership, Citizenship, and Transformation," in *2024 IEEE International Conference on Computing (ICOCO)*, 2024, pp. 302–307. https://doi.org/10.1109/ICOCO62848.2024.10928205.

[30] Y. Thakur, B. P. Alapatt, J. P. George, and R. Baby, "Enhancing Digital Citizenship Through Secure Identification Technologies in the Global Unified Digital Passport," in *2024 International Conference on Trends in Quantum Computing and Emerging Business Technologies*, 2024, pp.

1–5. https://doi.org/10.1109/TQCEBT59414.2024.10545059.

[31] A. Budiyanto, L. E. Nugroho, and P. I. Santosa, “Identification of Important Factors in Digital Citizenship Learning Curriculum,” in *2022 IEEE Integrated STEM Education Conference (ISEC)*, 2022, pp. 209–214. https://doi.org/10.1109/ISEC54952.2022.10025120.

[32] P. Ciancarini, R. Giancarlo, and G. Grimaudo, “Digital Transformation in the Public Administrations: A Guided Tour for Computer Scientists,” *IEEE Access*, vol. 12, pp. 22841–22865, 2024, https://doi.org/10.1109/ACCESS.2024.3363075.

[33] S. M. Anggara, A. Hariyanto, S. Suhardi, A. A. Arman, and N. B. Kurniawan, “The Development of Digital Service Transformation Framework for the Public Sector,” *Ieee Access*, vol. 12, pp. 146160–146189, 2024, https://doi.org/10.1109/ACCESS.2024.3406571.

[34] A. Kopponen *et al.*, “Empowering Citizens With Digital Twins: A Blueprint,” *IEEE Internet Comput.*, vol. 26, no. 5, pp. 7–16, 2022, https://doi.org/10.1109/MIC.2022.3159683.

[35] N. H. Waryanto *et al.*, “Fuzzy Logic-Based Clustering of Teacher Digital Pedagogy Using Cybergogy Framework for Sustainable Educational Innovation,” *Adv. Sustain. Sci. Eng. Technol.*, vol. 7, no. 3, p. 2503017, 2025, https://doi.org/10.26877/asset.v7i3.1946.